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Vol. 5 **July, 1922** **No. 7**

ORIGINAL PAPERS

THE TENSILE STRENGTH OF PORCELAIN[1]

F. H. RIDDLE AND J. S. LAIRD[2]

ABSTRACT

A method of accurately determining the tensile strength of porcelain has been developed.

The ratio of tensile to compression strength was found to be 5.9 for the special porcelain studied. Triaxial porcelains gave an average ratio of 7.66.

The tensile strength tests show in general a little more variation than compression strength tests.

The tensile strength is of more significance in judging the quality of porcelain than it has been commonly considered.

Introduction

Determinations of the tensile strength of porcelain appear to have been made only rarely, apparently on account of the experimental difficulties involved, and the uncertainty of the results obtained. Friese[3] reports tensile strengths of 1300–2000 kg. per cm. (18,480–28,440 pounds per sq. in.), on the basis of tests made with special test specimens. These results appear very high. Rosenthal and Singer[4] state that the determination of tensile strength is very difficult and report 261 kg. per sq. cm. (3,712 pounds per sq. in.) as the approximate strength of their insulator porcelain.

[1] Contribution from the research laboratories of the Champion Porcelain and Jeffery-Dewitt Insulator Companies.

[2] Received April, 1922.

[3] "Das Porzellan als Isoler und Konstruktions material in der Elektrotechnik," p. 41.

[4] Rosenthal and Singer, *Keram. Rund.*, **29**, 81 (1921).

Watts[1] in a study of electrical porcelain made tensile strength determinations. His specimens were molded by hand in the metal molds used in cement testing and had a cross-section of one square inch. They were broken in a standard cement testing machine, the shoulders of the specimens being cushioned with pasteboard. Only two specimens of each body were tested, so we cannot determine how consistent his results were. He found strengths for cone 10 triaxial porcelains properly vitrified varying from one to three thousand pounds per square inch.

In general, however, the assumption has been made that the strength of porcelain could be determined only by cross-breaking or compression tests. Against the former of these tests may be urged the uncertainty of the modulus of rupture formula as applied to porcelain, and against the latter, the expense of the equipment necessary.

A method of determining the tensile strength of porcelain which appears to give really significant results has recently been reported from this laboratory.[2]

Comparison of the strengths of different porcelain or other clay bodies can be made by this method by means of a small (2000 lb.) inexpensive, tensile test machine, of the type used in testing Portland cement; thus bringing such investigations within the reach of the laboratory of almost any clay-working plant. The results are apparently at least as reliable as those obtained by compression tests, while tests of this type (compression) are possible only when the laboratory is equipped with a testing machine of large capacity, 50,000 to 100,000-lb. capacity at least; and so are out of the question for most clay-working plants.

Apparatus Used

Two types of test specimens have been devised, designed to eliminate as far as possible transverse stresses and excessive local stresses which would tend to produce shattering. Either of these specimens, having a minimum cross-section of 0.125–0.2 sq. in., may be broken in an ordinary 2000-lb. Olsen cement testing machine provided with special grips (Fig. 1).

Test specimen No. 1, Fig. 2, has conical ends or shoulders which make an angle of about 15° with the straight portion in the center (see Fig. 2). The test specimen T is held by small steel clamps consisting of the split bushing B ground to fit the fired specimen and held by the collar C, the load being applied through the ball and socket joint by means of the plate P_1 held in slots in the jaws of the testing machine. A soft gasket G of blotting paper is inserted between the porcelain and the bushing to distribute the load, or else the porcelain will fail with a small load by splitting into thin

[1] Watts, *Trans. Am. Ceram. Soc.*, **4**, 86–130 (1902).

[2] Riddle and Laird, *Proc. A. S. T. M.*, **21**, 1050–56 (1921).

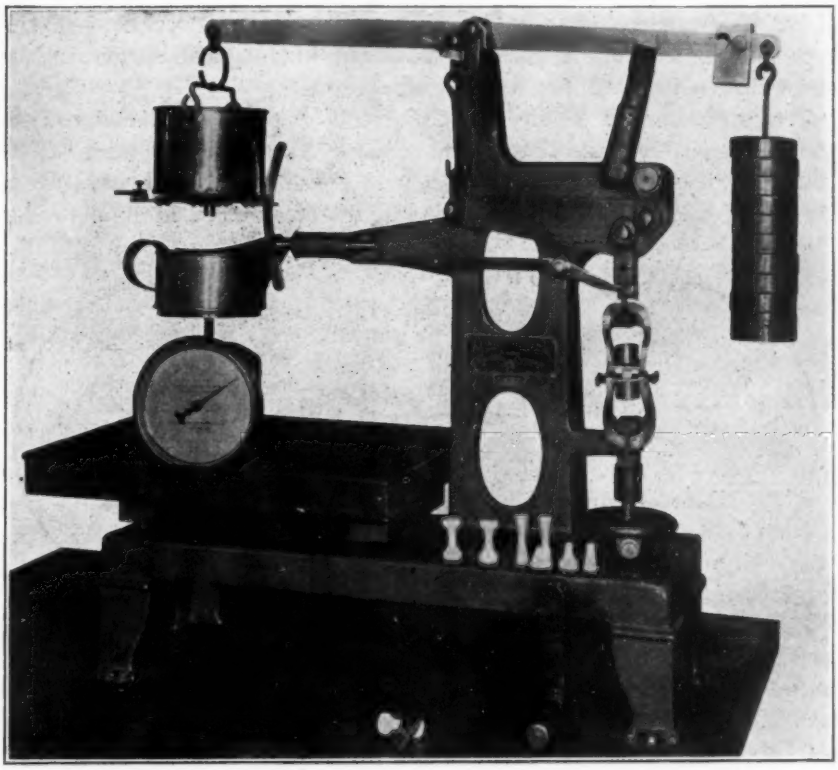

FIG. 1.
Testing machine used with 0.4–0.5-in. test pieces.

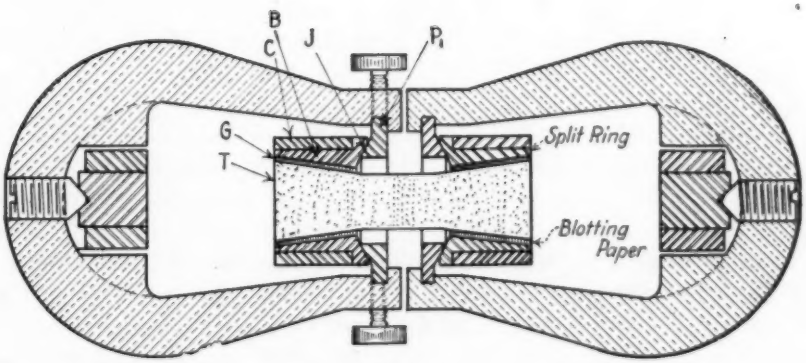

FIG. 2.

disks. A fresh gasket is used with each specimen. Specimens of this type may be used either glazed or unglazed, but must be of uniform size and shape or they will not fit the clamps.

Test specimen No. 2 (Fig. 3) is dumb-bell shaped, the diameter of the ends being about twice that of the reduced central portion (see Fig. 3). In testing, it is held by a split ring R with the same radius of curvature as the shoulders of the specimen. This ring fits into a recess in the plate P-2,

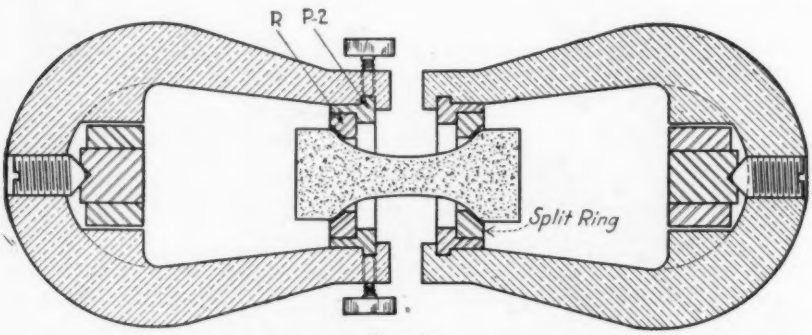

FIG. 3.

which in turn is held in the slots in the jaws of the testing machine. No gasket is required with this piece if the shoulders are glazed, but satisfactory results have not been obtained with unglazed pieces even by using a gasket.

Of the two types, No. 1 appears to give slightly higher results; possibly on account of its shape it stands firing better. The second type requiring no gasket permits of more rapid manipulation, and is more satisfactory when there is any considerable variation in size or the pieces have warped in firing.

Preparation

Test specimens have been prepared by pugging and extruding rolls of suitable size, throwing rolls by hand, and by cutting blanks from large pugged and cast blocks. It has been found that different strengths are shown by specimens prepared in different ways, and for comparative tests there must be strict adherence to one standard method of preparing the blanks. The blanks are turned in the green condition to such dimensions as will give fired specimens of standard size, shrinkage being determined and allowed for as in regular ceramic practice. The minimum cross-section of the fired specimen is determined by calipering and averaging a number, the variation from standard dimensions being kept within very narrow limits as it has been found that with specimens of about 0.2 sq. in. the calculated tensile strength increased about 0.5 per cent for a decrease in an area of 1 per cent.

When dry, the shoulders of the specimens are glazed, the central portion of minimum cross-section being left free from glaze to avoid the effect of the glaze in increasing or decreasing the strength of the specimens. This glazing of the shoulders is necessary with specimens of the second type, and is employed with those of the first type for the sake of uniformity and to insure that failure occurs in testing in the central cross-section of the specimen.

The glazed test pieces are fired on end in sagger usually on a little placing sand or in clay bats. Completely covering the specimens with sand causes them to break in firing. The specimens are burned in the regular porcelain kilns (or where noted in special experimental kilns). Specimens which warp in firing give unreliable results and should be rejected.

Results Obtained

A large number of tests have been made with porcelain specimens prepared and tested as described above. The consistency shown by the results indicated that this method gives an accurate measurement of the relative strengths of different porcelains, agreeing with the results shown in using the porcelain on a commercial scale.

In a series of tests the average variation of a single determination from the mean of the series is 14 to 15 per cent, the maximum variation, 30 to 40 per cent. It is therefore necessary to test 15 to 20 specimens to obtain a value reliable to a few per cent. This refers to porcelain which has been satisfactorily prepared and fired. Specimens which have been subjected to considerable variation in heat treatment, or have been subject to strains in forming so that they warp on firing are much less uniform.

TABLE I

TENSILE PROPERTIES OF PORCELAIN

Test specimen	Aver. cross-section area, sq. in.	Aver. load, lbs.	Aver. strength, lbs. per sq. in.	Variation per cent Aver.	Max.
	TRIAXIAL PORCELAIN				
No. 1 (conical)	0.131	816	6249	15.0	39.7
No. 2 (dumb-bell)	0.127	731	5760	15.6	23.2
	SPECIAL PORCELAIN				
No. 1 (conical)	0.129	1320	10250	17.7	37.9
No. 2 (dumb-bell)	0.130	1211	9390	15.1	33.9

Table I gives the results of a typical series of tests, the specimen blanks being formed by pugging. About twenty specimens were tested in each case.

On the basis of the tests which have been made by this method we have determined that good triaxial porcelain has a strength of 3000 to 6000 lbs. per sq. in., calculated from the breaking strength of specimens of 0.4 in. in diameter. Special high temperature porcelains show strengths running up to 10,000 to 12,000 lbs. per sq. in.

Comparison with Compression Tests

Compression test specimens were prepared by pugging rolls of special porcelain body with a diameter of one inch (after firing). After drying these were cut to give a fired length of about 2.5 inches on a specially designed wheel so that the two ends were truly parallel and as nearly as possible at right angles to the axis of the cylinder. A number of these specimens were fired in the same sagger with a number of tensile test specimens prepared from the same porcelain body. Four separate lots were fired and tested.

They were crushed on a large Olsen testing machine of 100,000 pounds capacity. In some cases the specimens were in direct contact with the iron compression plates of the machine. In other cases thin sheet lead was inserted between the porcelain and the iron to eliminate inequalities. The latter method gave results which were a little more uniform, but a little lower on the average. Failure under test with these specimens was a little peculiar, as in most cases there first occurred a splitting of the specimens into longitudinal segments. Then the load could sometimes, particularly when using the lead cushions, be increased considerably before complete failure occurred by crushing into many small fragments. About twelve specimens were tested in each experiment, and the results given are averages of all the specimens tested.

TABLE II

	Experiment	Area, sq. in.	Load, lbs.	Strength, lbs. per sq. in.	Variation, per cent	Ratio
1.	Tension	0.134	1,251	9,292	16.4	1:5.74
	Compression	0.760	40,071	53,355	13.1	
2.	Tension	0.135	1,244	9,194	21.8	1:6.27
	Compression	0.760	43,899	57,720	16.3	
3.	Tension	0.135	1,454	10,749	11.1	1:5.79
	Compression	0.760	47,405	62,335	12.1	
4.	Tension	0.133	1,285	9,639	23.9	1:5.92
	Compression	0.760	43,410	57,080	12.4	
				Average Ratio		1:5.90

The variation in strength of the tensile test specimens is in general a little greater than that of the compression test specimens. The ratios between tensile and compression strengths show quite satisfactory agreement.

The ratio between tensile and compression strengths is undoubtedly affected by variations in the preparation of the specimens and possibly varies with changes in the composition of the porcelain. As determined for twenty-two triaxial porcelains it averaged 7.66, as compared with 5.90, the average results obtained with special high-fire porcelain.

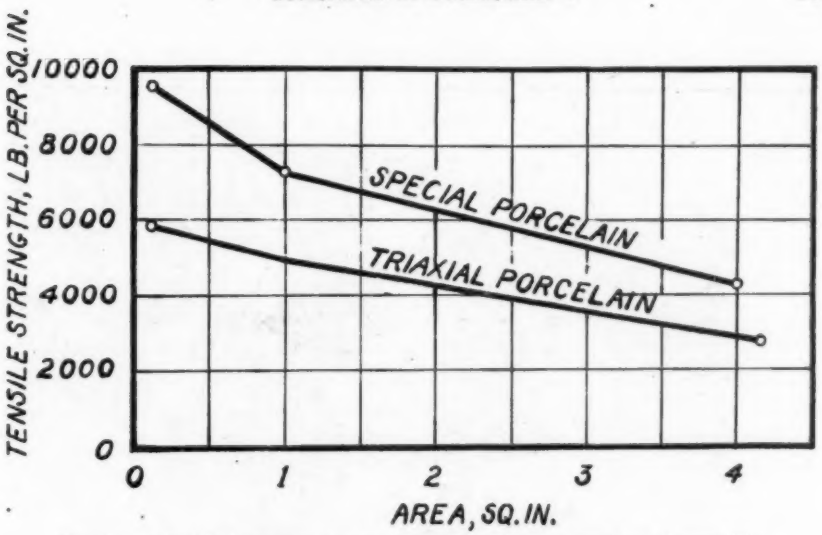

FIG. 4.—Relation between tensile strength and cross-section of porcelain.

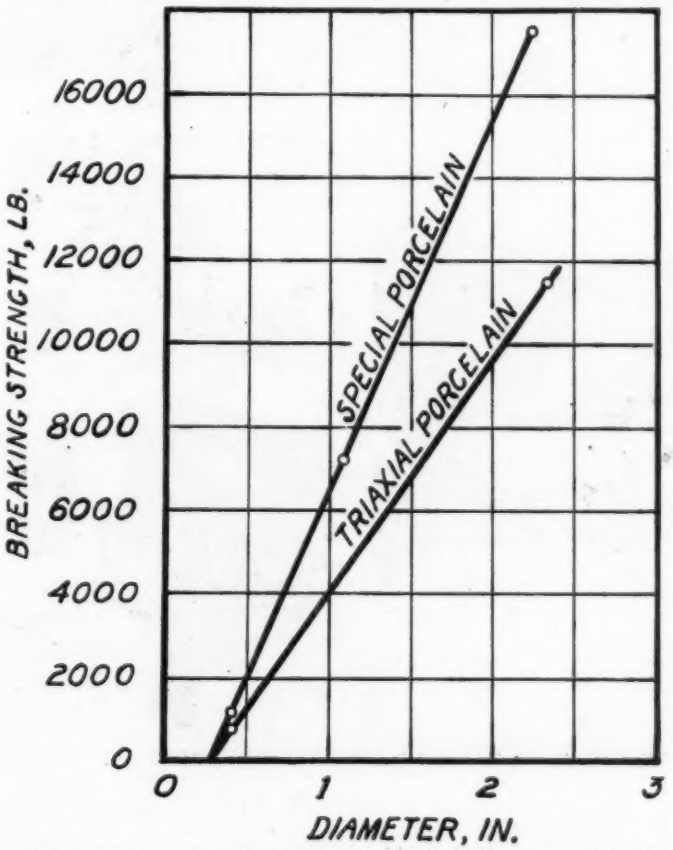

FIG. 5.—Relation between breaking strength and diameter of porcelain test specimen.

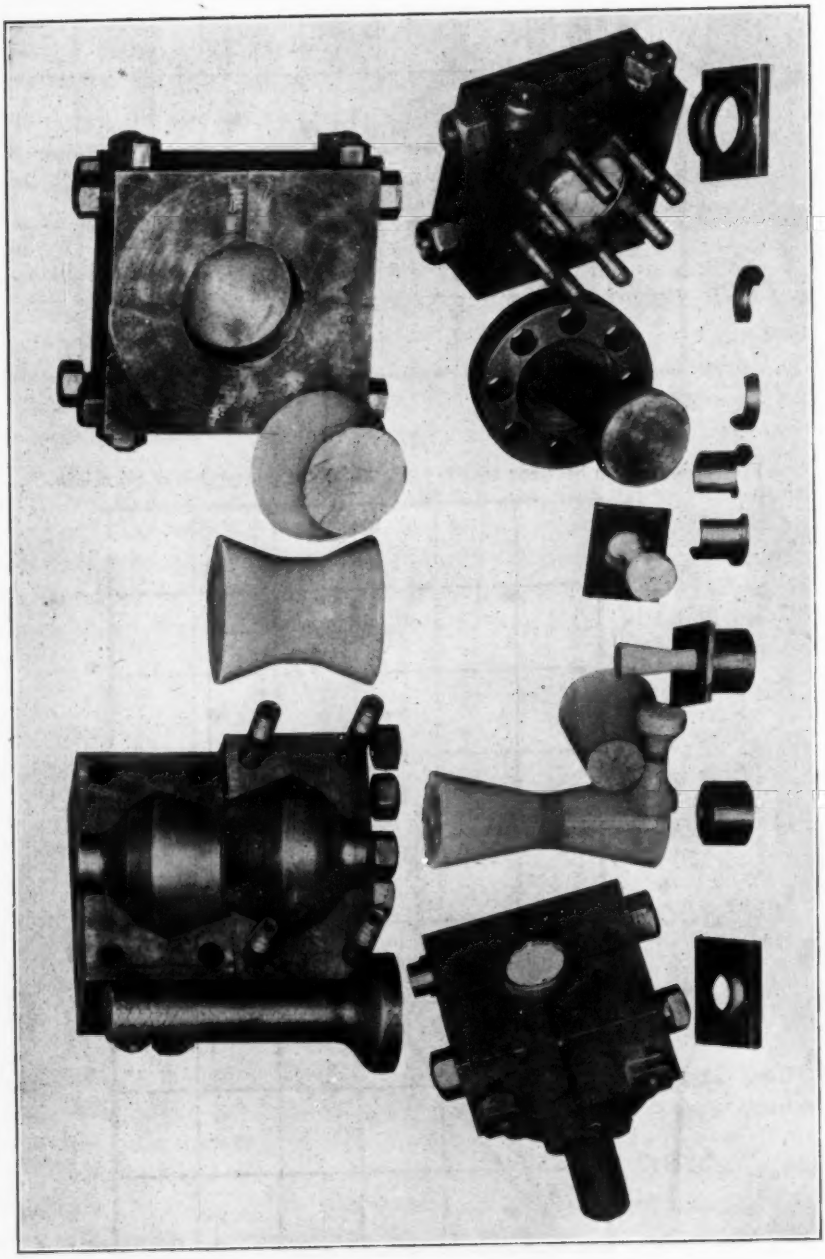

FIG. 6.—Test specimens of different sizes and grips used in breaking them.

Unfortunately in the case of the triaxial porcelains the tensile and compression test specimens were not fired together. It should also be noted that in these compression tests, which were made at the Bureau of Standards, the ends of the compression test specimens were ground and polished after firing. This may have given higher results than were obtained with our specimens which were ground but not polished.

It should also be noted that these ratios are dependent on the size of test specimen. The calculated tensile strength, decreases markedly with increase in cross-section of the test specimen. As reported in the article mentioned, tests with specimens of 0.4″, 1.125″ and 2.25″ diameters showed an increase of breaking strength almost proportional to the increase in diameter instead of to the increase in area. This relation is expressed approximately by the equation: $S = (d - 1/4)\,\frac{S_2}{d_2 - 1/4}$; where S = *strength of specimen*, d = *diameter of specimen*, S_2 = *strength of small specimen*, d_2 = *diameter of small specimen*. This is shown in the accompanying diagrams (Figs. 4 and 5). Fig. 6 illustrates grips and different sized specimens.

From a practical point of view the results obtained by means of this tensile strength test have been found to be very significant not only in cases when the porcelain is loaded in tension, but also when it must resist impact shock. In the case of impact resistance particularly, the tensile strength seems to give a more reliable indication of the value of the porcelain than the compression strength.

A SIMPLIFIED METHOD OF DETERMINING THE DRY VOLUME OF CLAY BRIQUETTES

By J. L. Crawford[1]

ABSTRACT

The dry volumes of clay briquettes for use in a draw trial burn are determined by dividing the dry weight by the bulk specific gravity. This method eliminates saturation of the test pieces with kerosene.

In testing a number of clays, the writer experienced considerable difficulty in determining the burning shrinkage when the standard method of the American Ceramic Society and of the American Society for Testing Materials was used. This method involves the saturation of the dry briquettes with oil and necessitates considerable weighing when a large volume of work is being done. It is often extremely difficult to remove the last traces of kerosene and when this is not done the briquettes break or crack upon being heated. Consequently, the results obtained by this method show numerous irregularities. In view of these results, several modifications were applied in order to eliminate the oil saturation and lessen the number of weighings.

The following method of procedure was finally developed. Four or five extra briquettes are made, weighed dry, and saturated with kerosene. Their volumes are determined in the usual way and the bulk specific gravities[2] determined by formulas 1 or 2.

$$\text{Bulk sp. gr.} = \frac{\text{Dry weight}}{\text{Volume}} \quad \text{(by volumeter)} \qquad (1)$$

$$\text{Bulk sp. gr.} = \frac{\text{Dry weight} \times \text{S. G. kerosene}}{\text{Saturated wt.} - \text{suspended wt.}} \quad \text{(by weighing method)} \qquad (2)$$

The remainder of the test pieces are simply weighed dry and their volumes are determined by means of formula 3.

$$\text{Volume} = \frac{\text{Dry weight}}{\text{Bulk specific gravity}} \qquad (3)$$

When this method was applied to several clays and mixes the maximum variation of the bulk specific gravity from the mean was found to be .005,

Table I

Material	Grog and plastic clay A	Plastic fire clay B	Brick clay C	Flint clay D	Washed pot clay E
1	1.960	1.525	2.000	1.860	1.875
2	1.960	1.525	2.010	1.860	1.870
3	1.970	1.525	2.010	1.850	1.875
4	1.960	1.520	2.000	1.860	1.870

[1] Industrial Fellow of the Mellon Institute of Industrial Research, University of Pittsburgh, Pittsburgh, Pa.

[2] The bulk specific gravity is defined as the specific gravity of the composite piece.

with a balance accurate to .05 grams. The results in Table 1 are typical for the specific gravity check determination.

Data that give a direct comparison between this method and the standard method are also available. Twenty briquettes (F) were made from plastic clay and twenty were made containing 50 per cent of grog (G). The volume of each briquette was determined by each method. The results of this comparison are given in Table II and demonstrate that the modified procedure is equally as accurate as the standard.

Subsequent application of the modified method further demonstrated that the volume change curves were smoother and freer from erratic results. This fact is undoubtedly due to two causes, the decreased handling of each test briquette, and the omission of the oil saturation. When the latter does not actually cause cracking or breaking it undoubtedly causes flaking to a smaller degree.

TABLE II

	F			G		
	Measured[1] vol., cc.	computed[2] vol., cc.	Bulk sp. gr.	Measured vol., cc.	computed vol., cc.	Bulk sp. gr.
1	21.80[3]	21.80	1.785[4]	20.55	20.55	1.965
2	20.30	20.30	1.780	23.50	23.45	1.960
3	19.30	19.30	1.785	24.75	24.80	1.970
4	21.50	21.55	1.790	22.50	22.55	1.965
5	18.65	18.60	1.785	22.05	22.05	1.960
6	18.25	18.25	1.785	23.70	23.75	1.970
7	21.50	21.55	1.790	23.90	23.90	1.965
8	18.90	18.90	1.790	25.85	25.80	1.960
9	18.80	18.75	1.780	22.95	23.00	1.970
10	19.75	19.80	1.790	23.80	23.85	1.965
11	19.25	19.25	1.780	22.85	22.85	1.965
12	24.05	24.05	1.785	20.75	20.80	1.970
13	19.60	19.65	1.785	26.95	27.00	1.970
14	19.25	19.25	1.785	23.65	23.70	1.970
15	19.80	19.75	1.780	24.05	24.05	1.970
16	20.05	20.05	1.785	25.90	25.90	1.970
17	20.75	20.75	1.785	22.65	22.70	1.960
18	20.10	20.10	1.785	22.00	22.00	1.965
19	18.50	18.55	1.780	24.75	24.75	1.970
20	18.65	18.60	1.785	22.05	22.05	1.965
Average			1.785			1.965

[1] Determined by old method—saturated weight minus suspended weight.

[2] Determined by new method—dry weight divided by bulk sp. gr.

[3] The volumes are computed to the nearest 0.05 cc.

[4] The bulk specific gravities are computed to the nearest 0.005.

It is, therefore, unnecessary to saturate any of the briquettes used in a draw trial burn with kerosene. It is only necessary to saturate a few briquettes which were made under the same conditions in order to determine the average bulk specific gravity of all the briquettes. The volumes of those to be fired may be calculated from their dry weights and bulk

specific gravities. This modified method lessens the number of weighings and eliminates oil saturation of the pieces to be burned. This results in a saving in time spent in weighing. It also results in eliminating the difficult task of drying the oil saturated pieces, in preventing cracking in the furnace, and in giving a smoother burning curve.

In conclusion, the writer maintains that in determining the volume burning shrinkage of a clay it is quicker, simpler and more accurate to calculate the dry volume of the briquettes from the dry weight and bulk specific gravity as explained above than to saturate each briquette in kerosene.

MELLON INSTITUTE OF INDUSTRIAL RESEARCH
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Discussions

BY E. W. WASHBURN:—The simplest and most convenient, as well as the most rapid and most accurate, method of determining the dry volumes of clay briquettes is by the use of a properly constructed mercury volumeter. For example, with the rapid porosimeter (*Jour. Am. Ceram. Soc.*, **5,** 125, Fig. 11) a determination of the bulk volume of a briquette to an accuracy of 0.02 cc. can be made in 2 minutes. No weighing is required. A somewhat more accurate result (*ca.* 0.005 cc.) can by obtained by using a volumeter of the type shown in Figs. 9 and 10 (*l. c.*) and weighing the mercury withdrawn.

BY E. N. BUNTING:—Mr. Crawford's procedure is an improvement upon the standard method when several determinations are made. However, it is not necessary to use oil to determine the bulk sp. gr., as the volume can be determined accurately and rapidly in a mercury volumeter of correct design. Briquettes of the same batch seldom differ in bulk sp. gr. by more than $^1/_2\%$, so the author's assumption that the bulk sp. gr. of any one briquette can be determined from the average bulk sp. gr. of a few is fairly correct.

BY H. H. SORTWELL:—The method of determining volumes described by Mr. Crawford is an excellent one from the standpoint of saving time, minimizing routine work, and eliminating the difficulty of safely removing the kerosene from the trial pieces. During the past year in a study of ball clays, a preliminary report of which appeared in *The Ceramist*[1] it was found to be practically impossible to completely remove the kerosene from some of the very plastic English ball clays in any reasonable length of time without damaging the pieces. In order to determine the volumes without saturating the pieces with kerosene a similar method was used in combination with the Schurecht pycnometer. In the writer's judgment Mr. Crawford has presented enough data to show that this method is sufficiently accurate for all practical testing.

[1] "The Properties of Some Ball Clays," H. H. Sortwell, *The Ceramist*, **2,** 5 (1922).

FIRE CLAYS OF THE EASTERN COALFIELD OF KENTUCKY[1]

By H. Ries[2]

ABSTRACT

The eastern coalfield of Kentucky contains two horizons of workable refractory clays. One of these bearing flint, semi-flint and plastic clay is definitely proven to be of upper Pottsville age, and rests unconformably on the Mississippian formations. The other found in Boyd and eastern Carter County is in the Allegheny series and carries plastic fire clay of less commercial value. A number of points, not hitherto emphasized or noted are described.

The fire clay deposits of the eastern coalfield of Kentucky have long been known, and serve as the basis of a flourishing refractory product industry. They have, moreover, been discussed from time to time by different writers,[3] so that it might seem superfluous to devote any more space to them, and the main reason for doing so is for the purpose of bringing out certain facts, not hitherto mentioned, and others regarding which there may be a difference of opinion with previous investigators.

Formations of the Eastern Coalfield

The bed rock formations occurring in that part of Kentucky lying roughly east of a line drawn from opposite Portsmouth, Ohio, through Irvine and Somerset, Kentucky, range from Silurian to Pennsylvanian in age. The pre-Pennsylvanian formations contain, so far as known, no clays of refractory character, and consequently it is only the Pennsylvanian strata that concern us.

The formations of the last-named system of rocks, which underlie the greater part of the area under discussion, are represented by the Pottsville, Allegheny, and Conemaugh series, named in ascending order. Of these, only the Pottsville and Allegheny have so far yielded refractory clays.

Pottsville Clays.—At the bottom of the Pottsville series as exposed in Carter, Boyd, Elliott and Rowan Counties there is found an extensive, but not continuous, deposit of fire clay, which has assumed great industrial importance, and which is often referred to as the Olive Hill fire clay, because of the locality in Carter County, where it was first developed.

Character of the Olive Hill Fire Clay.—This fire clay deposit is made up of three different grades known as: (1) Flint, (2) Semi-hard, soft-hard or semi-flint, and (3) No. 2 plastic.

The flint clay is very fine grained, has a conchoidal fracture, and in color is often buff or gray, but sometimes dark gray, black, or even red. It

[1] Published by permission, State Geologist of Kentucky.

[2] Refractories Division, St. Louis Meeting, Feb. 28, 1922.

[3] A. F. Crider, *Ky. Geol. Surv.*, 4th Ser., **1**, II (1913); S. L. Galpin, *Trans. Am. Ceram. Soc.*, **14**, 301 (1912); A. F. Greaves-Walker, *Ibid.*, **9**, 461 (1907).

occasionally grades into a sandy phase, which contains minute grains of quartz.

At a few localities an oölitic variety of flint clay is found, which contains small oölites imbedded in a matrix of normal flint clay. This variety was described by Greaves-Walker[1] as occurring in the Burnt House mine (now abandoned) at Olive Hill and he proposed the name of *Aluminite* for it. A peculiarity was its high percentage of alumina, which is due as shown by Galpin,[2] to the fact that the oölites are composed of gibbsite (Al_2O_3, $3H_2O$).

This type is not found in any of the other mines around Olive Hill, but Crider[3] has noted its occurrence at several other localities.

While the flint clay shows high refractoriness, the deposits may occasionally show impurities such as pyrite concretions, and films of gypsum, the latter occurring in the irregular cracks that traverse the flint clay in all directions, but not in sufficient quantity to reduce its refractoriness. Quartz grains are present where the flint clay grades into sandstone.

A microscopic study of the flint clay by Galpin[4] shows that the flint clay contains kaolinite, hydromica, pyrite, quartz, rutile, zircon, and tourmaline, but all except the first two, only in small amounts. Gibbsite was found only in the oölitic clay.

The semi-hard clay differs from the flint in being slightly softer, in having noticeable plasticity, and in showing the presence of numerous slickensided surfaces which commonly traverse the flint clay in all directions, although occasionally they follow a prevailing one.

It is usually quite sharply separated from the flint clay, but like the latter may contain pyrite concretions and gypsum films. In some mines it shows minute white specks about $^1/_{32}$ inch diameter, which may be gypsum. Hydromica is more abundant than kaolinite.

The No. 2 plastic clay, differs from the other two in having decided plasticity. It is softer than the semi-hard, but shows an abundance of slickensides, and is the least refractory of the three. In some cases it can be used for a lower grade of fire brick.

Relations of the Three Fire Clays.—Some of the previously published sections may lead one to infer that the three clays above mentioned occur in rather regular beds within the deposits, but a careful comparison of the sections studied in different mines brings out the fact that there is no definite order of deposition. It is true that a definite relationship may hold throughout one mine, but it does not hold in all parts of the area in which these clays occur. In some mines practically nothing but flint clay may occur, in others only semi-hard, but none was seen where No. 2 plastic

[1] *Trans. Am. Ceram. Soc.*, **9**, 461 (1907).
[2] *Ibid.*, **14**, 301 (1912).
[3] *Ky. Geol. Surv.*, 4th Ser., **1**, II, 589 (1913).
[4] *Loc. cit.*

alone is found. It is not common however to find any one variety forming the entire deposit in any one mine.

Extent of Fire Clay Deposits

The three associated fire clays just described are found throughout a wide area of territory extending from the Ohio River on the northeast, to Elliott County on the southwest, although the deposit is not a continuous one, for the clays are wanting in spots due either to non-deposition or erosion.

The former condition is indicated by the fact that the fire clay at places grades laterally into a sandstone and the latter condition by the occasional close but unconformable contact between the Pottsville conglomerate and the lower lying Waverly beds of the Mississippian system. Along the line of the Chesapeake and Ohio Railway they are found from Aden on the east to Morehead on the west.

FIG. 1 —Entrance to mine of Ashland Fire Brick Co., Hayward, Carter Co., Ky.

Roughly speaking the area within which the fire clay deposits have been found outcropping is about 660 square miles.

Within this area the development has been chiefly in a zone bordering the Chesapeake and Ohio Railway, but some companies have built narrow gauge railroads to mines 4 or 5 miles distant from the main rail line.

Much drilling has, however, been done in practically all parts of the area,

and reserve supplies blocked out, so the several fire brick companies either own extensive undeveloped clay lands, or control the mineral rights on them. There is, no doubt, a large reserve tonnage in the district as a whole but it is impossible to state exactly how many years it will last, although there is no danger of early exhaustion. To the east of Aden the fire clay passes below the surface since the strata dip in that direction, and that it probably continues with depth is shown by the fact that about one mile east of Denton, Boyd County, it was struck at a depth of 625 feet below the surface.

The thickness of the fire clay as determined from a study of the beds and drill records ranges from almost zero to 29 feet, the larger figure representing a bed of solid flint clay said to have been struck in boring.

Relation of Fire Clay to Underlying Formations

At most localities where the fire clay occurs the Maxville limestone is found below, but not always in actual contact with it. Erosion which preceded the deposition of the fire clay, has cut the limestone to a variable degree in different places, and in cases has removed it completely as at Iron Hill, Carter County, where, according to Crider,[1] the flint clay rests directly on Waverly sandstones and shales.

Only rarely does the fire clay rest directly on the limestone, being usually separated from it by a red mottled plastic clay known as "pinkeye," by sandstone or by shale. Crider has stated that the pinkeye is calcareous and furthermore that it is a residual deposit derived from the Maxville limestone. So far as my observations go, I have not observed any pinkeye that is calcareous, nor should one expect it to be if it is residual, as weathering usually leaches the lime carbonate out of a rock. Nor can I agree with him that it represents a residual deposit from the Maxville limestone, because sometimes there is sandstone between the two.

As a rule the pinkeye is of low refractoriness, but occasionally it is sufficiently refractory to be used in fire brick.

Immediately on top of the limestone there is sometimes a cherty mass that appears to have been altered by weathering, and which may be from 1 to 3 feet thick. A good section of this is seen in the mine of the Ironton Fire Brick Company near Enterprise, Carter County.

The interval between the bottom of the fire clay and the top of the Maxville limestone is exceedingly variable. Data obtained from sections at mines and from drill records which I was kindly permitted to examine show that this interval ranged from one foot eight inches to 25 feet. One section showed 22 feet of shale between the fire clay and the limestone, in another there was sandstone between the pinkeye and fire clay, while in

[1] *Loc. cit.*

still other cases the floor of the fire clay was pinkeye in one place and sandstone in another, even within the same mine.

There is no doubt that the fire clay is separated from the Maxville limestone by an unconformity, and this break may be above the shale and sandstone sometimes found overlying the lime rock. That this unconformity represents not only uneven erosion, but also considerable erosion in places, is shown by the variable thickness of the limestone which ranges from 0 to 100 feet, the former figure being represented by one drill hole in which the fire clay was found resting on the Chester sandstone (Crider).

It is probable that some of the soft sandstone associated with and grading into the fire clay, as well as the pinkeye clay, are above the unconformity.

Relation of Fire Clay to Overlying Formations

The rock immediately overlying the fire clay may be shale, sandstone, coal, coarse conglomerate, or Pottsville pebbly sandstone.

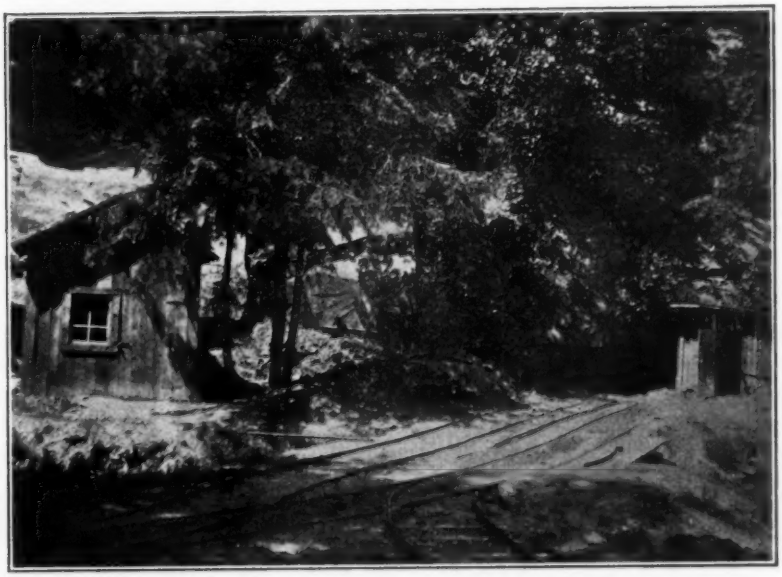

FIG. 2.—Entrance to mine of Louisville Fire Brick Works, Grahn, Carter Co., Ky. Shows Pottsville pebbly sandstone roof, over fire clay.

While the coal is usually above the fire clay, and often rests directly on it, there are times when it occurs within the fire clay near its upper limit. It may be entirely absent, and in any event is rarely over six inches thick.

The shale when present is conformable with the clay, and is sometimes quite carbonaceous. It may also contain concretions of siderite and pyrite.

At Hayward, for example, there is between the shale and fire clay a hard, fine grained sandstone, known as "whim rock," which contains small angular particles of flint clay.

At Grahn, the Pottsville pebbly sandstone rests directly on the fire clay in places, but in one mine there are found flat lenses of a coarse conglomerate, consisting of pebbles up to an inch in diameter, in a matrix of quartz sand and mica scales. The pebbles are mostly quartz, but where the black shale lies between the fire clay and conglomerate, some of the pebbles are of shale and of siderite.

Here then there is an unconformity between the Pottsville pebbly sandstone and the fire clay and black shale. A similar unconformity has been noted in some other mines.

The thickness of the Pottsville pebbly sandstone above the clay is variable, and the range shown by a number of drill records is from 50 to 130 feet.

In this Pottsville sandstone above the fire clay, there may be one or several beds of a mottled clay known as "Huckleberry clay" which is said to be non-refractory. The thickness of these as encountered in different drill holes ranged from 2 to 15 feet, and the interval between the fire clay and the nearest bed of Huckleberry ranged from 2 to 35 feet.

In two holes where no fire clay was present there was 20 feet of sandstone between the Huckleberry and limestone in one case, and 39 feet of shales and sandstones in another case. In short, the Huckleberry does not appear to occupy any definite position in the section above the clay.

Age of the Olive Hill Fire Clays

While there has been much discussion regarding the geologic age of the flint and associated fire clays of the Olive Hill region, most writers have placed it in the Pottsville series of the Pennsylvanian, rather than in the Mississippian.

Most observers agree that the fire clay formation lies above the Maxville limestone of the Chester, a subdivision of the Mississippian, and that it is separated from the lime rock by an unconformity. Moreover, the clay miner and prospector look for the clay above the limestone.

This position of the clay above the limestone, and the unconformity has no doubt caused the majority of observers to place it in the Pottsville.

Miller[1] has however called attention to an occurrence of flint-like clay near Blairs Mill, Rowan County, which is overlain by Mississippian limestone, and has suggested, that this indicates that the clay is of the above-named age.

While there seems to be no doubt regarding the age of the "flint clay"

[1] *Dept. Geol. and For., Ky.*, Ser. V., *Bull.* **2**, 330 (1919).

which he refers to, the other evidence indicates that the Olive Hill flint clay is not of Mississippian age, because; (1) the so-called flint clay at Blairs Mill is not such, but is a clay of low refractoriness, (2) no limestone has been found above the fire clay in the hundreds of drill holes that have been put down in Greenup, Carter, Rowan and Elliott counties.

This it would seem rules out the theory that the clay is of Mississippian age. Further evidence is afforded by plant remains found immediately above the fire clay, and below the unconformity between it and the Pottsville sandstone, for these plants have been definitely identified by Dr. David White as of upper Pottsville age.

It would appear then that following the deposition of the Maxville limestone, and some shale and sandstone, there was a period of erosion which in places removed much or all of the lime rock. On this undulating surface there were deposited the pinkeye clay, semi-plastic fire clay and flint clay, the No. 2 plastic, and the thin seams of coal and carbonaceous shale. In places some thin deposits of iron ore also accumulated. There followed then another interval of erosion before the Pottsville conglomerate was deposited.

The Fire Clay of Allegheny Series

The Allegheny series of the Pennsylvanian contains a deposit of plastic fire clay associated with the Vanport or ferriferous limestone in parts of Carter and Boyd Counties.

In Boyd County[1] it usually lies 10 to 40 feet above the top of the Homewood (Pottsville) sandstone, and between coals Nos. 5 (Brookville) and 6 (Lower Kittanning). If coal No. 5 is absent the clay may lie even nearer the Homewood sandstone.

The fire clay outcrops in the hills both southeast and northwest of Ashland, and north of Catlettsburg.

The dip of the formations causes it to disappear near the mouth of the Big Sandy River, and it does not reappear north of Louisa in Lawrence County on the south. From Louisa it outcrops in the hills in the form of a great arc, following the outer edge of the basin, and coming back to the Ohio River at Ashland.

In Carter County the clay comes up with the dip and is seen above the C. & O. Ry. tracks about one mile east of Denton.

Near Hitchins the clay is found near the tops of the ridges and is not to be looked for any farther to the west.

The plastic fire clay while associated with the Vanport limestone, is sometimes above and sometimes below it. Indeed at some of the mines in Carter County no limestone is found with the fire clay, moreover even in the same mine the thickness of the limestone may vary.

[1] W. C. Phalen, *U. S. Geol. Surv., Bull.* **349**, 1918.

It has also been noticed in working the clay that it occasionally grades into material of lower refractoriness and more ferruginous character, necessitating abandonment of the entry or sometimes the mine.

It seems probable that at the horizon of the Vanport limestone there is a clay deposit of variable, and sometimes appreciable thickness, and that certain beds or lenses in this deposit may be of refractory character, but that these refractory beds do not all occupy the same position in the clay member, nor are they always of great extent.

The Vanport fire clay is usually plastic, but these are occasionally pockets of flint clay found in the plastic material.

The plastic clay is usually, mottled gray and yellow, and occasionally shows concretions of pyrite and thin films of gypsum. The thickness in different mines ranges from 3 to 10 feet, the floor being often a micaceous sandy clay.

Owing to the fact that the Allegheny plastic fire clay is not as refractory as the Pottsville flint and semi-hard clays it is less in demand, and when worked it is for the purpose of mixing with the more refractory clays found to the westward.

In the summer of 1921 the only mines in steady operation were those of the Ashland Fire Brick Company, northwest of Ashland, the Harbison-Walker Refractories Company, 2 miles south of Denton, and the General Refractories Company at Hitchins.

The section at the mine south of Denton showed:

Impure clay shales	50 ft.
Plastic fire clay	4½ ft.
Sandy micaceous clay	——

These clays average from cones 30–31 in their refractoriness. Some drop as low as cone 29 while others have tested as high as cone 33.

The Fire Brick Industry

With the development of the fire clays of eastern Kentucky, there has gradually developed a thriving fire brick manufacturing industry, which is supported mainly by the Pottsville refractory clays, the plastic fire clays of the Allegheny series being drawn upon to a lesser extent. Most of the plants are located in eastern Kentucky, but one is at Louisville and in addition the clay is shipped to factories in Ohio and Pennsylvania.

According to Crider,[1] S. Eifort, K. B. Grahn and J. McL. Stoughton purchased a large tract of land in the Olive Hill district about 1868, with the intention of erecting an iron furnace. As there was no railroad through the district then, the venture was unsuccessful.

[1] *Loc. cit.*

FIG. 3.—Plastic fire clay pit of General Refractories Co., Hitchins, Carter Co., Ky.

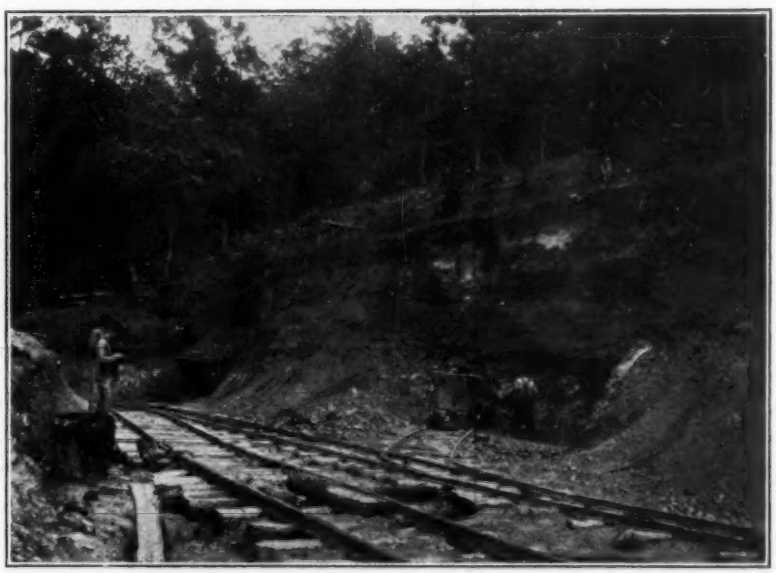

FIG. 4.—Plastic fire clay mine of Harbison-Walker Refractories Co., 2 miles south of Denton, Boyd Co., Ky.

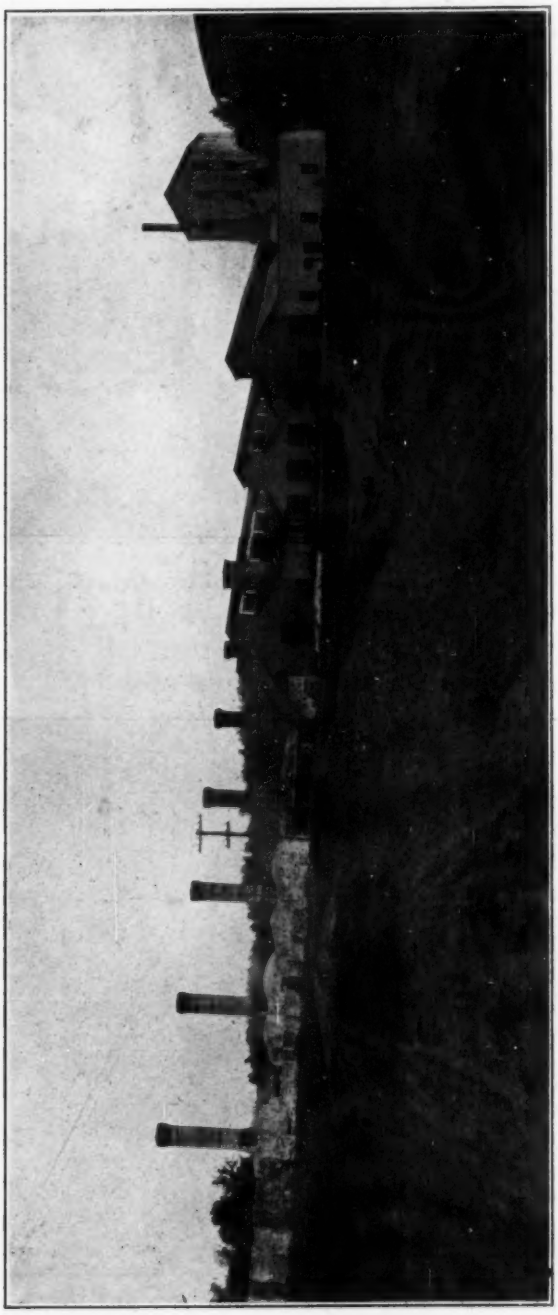

FIG. 5.

In 1871, Pottsville fire clays were mined in Lewis County and shipped to a fire brick works at Cincinnati. It is also stated that the plastic fire clays were made into fire brick at Bellefonte Furnace near Ashland, Boyd Co.

The first Olive Hill clay was shipped in 1883 to the Ironton Fire Brick Works at Ironton, Ohio, and the material was found so satisfactory that soon plants in Ashland, Cincinnati, Sciotoville and Louisville were using it.

About this same time, plastic fire clays were worked at Amanda Furnace, Ky., although they may have been worked at a still earlier date.

In 1885 the Ashland Fire Brick Company constructed a plant at Ashland, followed by the erection of another plant at the same place in 1890 by the Clinton Fire Brick Company. The latter company sold its plant to the former a few years later.

The Louisville Fire Brick Works, at Highland Park, Jefferson County, was started in 1889.

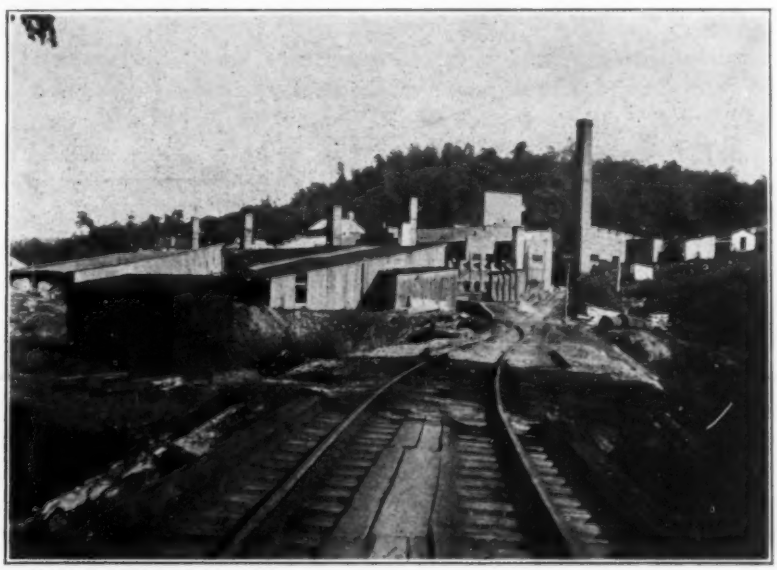

FIG. 6.—Plant of Ashland Firebrick Co., at Hayward, Carter Co., Ky.

It was not until 1895 that a plant, that of the Olive Hill Fire Brick Company, was built at Olive Hill. This was supplied from the Old Burnt House mine, now worked out, but said to have a deposit of fire clay 27 feet thick.

There followed then at intervals additional plants as follows:
1900. Ashland Fire Brick Company, Hayward, Carter Co.

1901. Harbison-Walker Refractories Company, Olive Hill, Carter Co.
1903. Kentucky Fire Brick Company, Haldeman, Carter County.
1909. General Refractories Company, absorbed plant of Olive Hill Fire Brick Company.
1911. Louisville Fire Brick Works, Grahn, Carter County.
1912. General Refractories Company, Hitchins, Carter County.

In addition Chas. Taylor's Sons of Cincinnati have taken over the former plant of the Tygart Fire Brick Company at McCall, Carter County.

These plants have an aggregate daily capacity of 535,000 expressed in terms of 9-inch brick.

While many of the mines are operated to supply local plants, there are others which are either owned and operated by fire brick manufacturing firms located outside of Kentucky, or by clay miners who own no plants.

CORNELL UNIVERSITY
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DEVELOPMENTS IN 1921 IN ELECTRIC VITREOUS ENAMELING FURNACES[1]

By James W. Carpenter

ABSTRACT

A summary of the new installations of electric furnaces during 1921 for vitreous enameling work with descriptions of various types of furnaces and operating data from various shops.

Progress of the most pleasing nature in the application of electric heat to vitreous enameling has been recorded during 1921. In that time industrial conditions in general have not been satisfactory and in the metal trades particularly there has been an extreme of depression. Despite this abnormal condition there has been a rapid development in electric enameling with new installations and improved methods of operation. A widespread interest has grown in this new field of the electric furnace and present indications point to a rapid expansion in electric furnace usage with the improvement gradually appearing in business conditions.

It was the privilege of the writer in association with Mr. C. W. Mehling to offer at the 1920 meeting of the American Ceramic Society a report on the operation of the first commercial application of electric heat to vitreous enameling in the factory of the St. Louis Brass Mfg. Co. It is the purpose of the present paper to give in brief fashion the advancements in the use of electric heat for vitreous enameling during 1921.

Since that report on the St. Louis Brass Mfg. Co. furnace, the installation has remained in steady operation and has continued its uniform production of white enameled reflectors of various shapes. It has also been used for color work, pipe work and cast iron jobs. In all cases the results have been of the very best quality. This furnace has been subjected to extremely hard usage as it was operated on night shift during the spring months. It was shut down for a brief period and then placed on day time operation during the summer months. Since October it has run on night shift again, 10 hours a night and six nights a week. This continual daily shutting down, starting up and change of schedule has not had the slightest apparent effect upon the furnace. The brick work and structural work are unimpaired, the elements from external inspection appear in first class condition, and the furnace in general is in excellent shape. The maintenance during the year has consisted of one thermocouple, a small coil and four dry cells on the Leeds and Northrup control apparatus and a box of fuse links for the main fuse block of the furnace circuit. During the year the furnace has been further improved in appearance and operation by the application of a thin coat of asbestos to the outer walls. This has saved a considerable amount of heat and has given an unusually clean appearance to the furnace.

[1] Read by Mr. Hain before the Enamels Division, St. Louis Meeting, Feb. 28, 1922.

A smaller furnace of two compartment design in the factory of the General Electric Company at Schenectady, N. Y., has been reported in *Chemical and Metallurgical Engineering* (1921) as giving similar satisfactory results. This furnace is used for the enameling of resistance tubes used in electrical apparatus manufactured by the General Electric Company. The furnace has a front chamber 48 inches long, 18 inches wide and 24 inches high, supplied with 9 kw. of electrical capacity and arranged as a preheating chamber. The material is placed in this chamber for approximately six minutes at a temperature of 570°F. It may then be moved back to the second chamber which is 48 inches long, 18 inches wide and 24 inches high. In this chamber the work is carried up to 1650°F for a period of four minutes. This second chamber has an electrical capacity of 24 kw. The data obtainable indicate that the load in the furnace will consist of 36 tubes or 27 pounds of material in one compartment and that the supporting tray will weigh approximately 30 pounds. It has been estimated that this small furnace has increased the production of the department where it is used about 50% over the old oil furnace and very favorable operating costs with the electric heat have been obtained in comparison with the previous requirements of 6 gallons of oil per hour.

The value of the electric furnace for another type of small piece enameling has been shown in the initial installation in an Illinois watch factory. This particular furnace is of the rotary type with a narrow refractory block supported on stools and rotated through three separate chambers. The plates to be enameled are sprinkled with the enamel in the dry process and then placed in the furnace and carried around on the rotating refractory. This furnace has given exceptionally satisfactory results in the quality of enamel finish.

The first application of the electric furnace to the enameling of stove parts has been made during the year in the factory of a Rochester, N. Y. stove company. The furnace for this work is somewhat similar in design to that of the St. Louis Brass Mfg. Co. although it is smaller in size and has an electrical rating of 95 kw. The approximate overall dimensions of this furnace are 8 ft. high, 9 feet deep and 7 feet wide. The heating chamber is composed of an upper and lower chamber about 42 inches wide, 5 feet deep and 23 inches high. The wall construction is approximately as follows: Fire brick lining on the inside with a minimum thickness of $4^1/_2$ inches at the side walls of the upper chamber and a maximum thickness of 9 inches at the arch. The lower chamber walls are also 9 inches in thickness. This fire brick enclosure is surrounded by a 9-inch lining of Sil-o-cel and there is then an outer shell of a single course of common red brick. The door consists of $4^1/_2$ inches of fire brick facing with $4^1/_2$ inches of Sil-o-cel, carried in a cast iron frame.

At present this furnace is being operated at from 1250 to 1350°F for

the enameling of cast iron stove parts. Four colors of enamel are being produced—white, black, gray and blue. The surfaces of the work are not pitted and when the castings are fractured, the enamel adheres very closely to the line of cleavage. Very shortly it is planned to put Armco iron parts used for gas ranges through the furnace when the temperature will be approximately 1600°F. The furnace is now operated at night from seven P.M. until the day shift of workers arrives at the factory and the power consumption approximates 10,000 kw. hr. a month. It has been determined that the production of the furnace is easily 700 pounds of metal per hour on cast iron parts enameled at a temperature of 1250°F.

FIG. 1.—Electric furnace for kitchen ware.

For the production of hollow ware an interesting installation has been made in a Chicago factory. This unit is arranged for double end operation. The inside length of the furnace is approximately 15 feet, divided into two equal sections and there is a door at each end. The width of the burning chamber is 42 inches and the height is approximately 2 feet. The power rating is 235 kw. for operation on 440 volts, 3 phase, 60 cycle service. The company operating this particular furnace is reported as being very pleased with the results of the few months of operation. They are turning out exceptionally good work and have entirely eliminated rejects due to improper burning. They have been able to increase the number of pieces placed on a fork from 14 to approximately 24 for a given charge and can thus use 100% of the hearth space.

Another large furnace placed in operation during the year is devoted to the enameling of bath tubs and such articles. This unit is a double chamber furnace constructed for operation on the old gas and coal furnace schedule of $2^1/_2$ tubs per hour but the electric furnace has gone right along with a considerably better production in each chamber. This furnace is notable for low operating cost, uniform heat, advantages obtained through automatic control of temperature, elimination of rejects and simplicity of operation.

Some of the operating data at present available on furnaces of the foregoing types are given in the following paragraph.

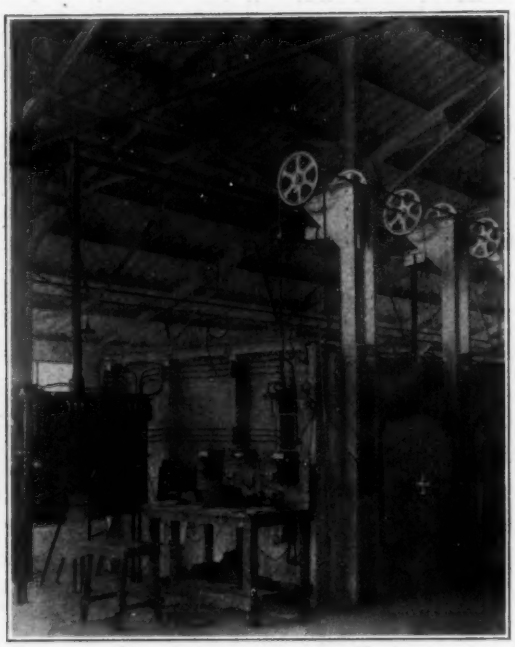

FIG. 2.—Electric furnace for bath tubs.

One furnace is arranged to deliver at least 25 heats of 110.4 lbs. per hour, as follows:

Supporting racks	60 lbs.
Steel ware	32 lbs.
Enamel	18.4 lbs.
Gross production per hour	2760 lbs.
Net production per hour	1260 lbs.

The net efficiency is approximately $6^1/_2$ lbs. of material burned per kw. hr. of power consumed. At the present time the furnace operates at 1750° F with the maturing temperature of the enamel at 1550°F.

For the furnace from which this data were secured, it was predicted that the quantity of tin oxide used in the enamel can be materially decreased because of the very positive temperature at which the electric furnace operates at all times. Likewise the production has been increased approximately 50% per unit of floor space and it seems probable as regards installation costs that the increased production will offset the greater first cost of the electric furnace.

In one factory two electric furnaces have replaced three coal furnaces, that is, the production of two electric furnaces is equivalent to the production of three coal furnaces. The cost of the coal itself, plus the labor for unloading coal and the firing, and the labor for removing the ashes, was equal to the cost of power consumed by two electric furnaces. This calculation was based upon 20-hour per day operation with coal at $4.60 per ton on the siding, and electricity at 1.8 cents per kw. hr. In addition, the

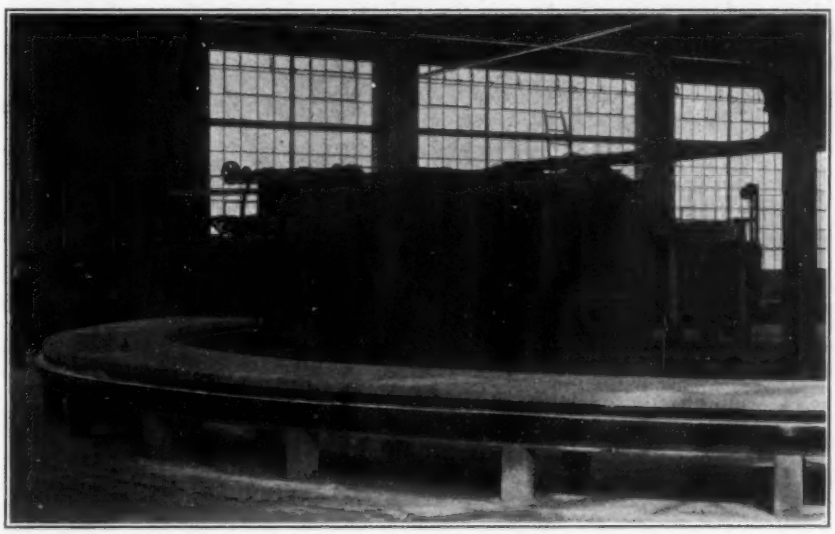

FIG. 3.

three coal furnaces required 7 men, 2 shifts each, while the two electric furnaces require only 4 men, 2 shifts each. The labor costs in the case of the three coal furnaces amounted, therefore, to $56 a day while with the two electric furnaces the labor cost was only $32 a day. With the lower labor cost and the equal fuel and power costs, the two electric furnaces have a net daily operating cost approximately $20 lower than that of the three coal furnaces.

New Design-Movable Furnace

During the past year plans were formulated for a revolutionary idea in

enamel burning. The fundamental thought in this new design of furnace is to carry the furnace over the ware to be enameled instead of placing the ware inside a stationary furnace. The initial installation based upon this principle was designed for a large enamel ware factory in Pennsylvania. The equipment has been installed and tested out for several days and it is expected that active production will be carried on just as soon as the factory building has been completed.

This installation may be described briefly as follows: There is a stationary circular platform which is 54 inches wide and 60 feet in diameter from center of table to center of table, giving a circumference of approximately 180 feet. The ware is to be placed by hand on this platform and the furnace proper revolves over the platform, moving along on a

FIG. 4.—Moving furnace—stationary ware.

standard railroad gauge track. The furnace chamber is 21 feet in length in the main section and attached to each end of this main chamber there is a hood 8 feet in length. There are doors at each end of the main chamber as well as at the ends of the hoods. These hoods are intended to prevent excessive heat losses from the main chamber as the doors are opened constantly just high enough to clear the ware.

The furnace is driven over the platform by a variable speed motor with a range of from $4^1/_2$ feet to 9 feet per minute, and as it is to be operated at an average speed of 7 feet per minute, the ware will be covered by the main heating chamber for a period of 3 minutes.

This furnace is supplied with 600 kw. of electrical capacity but it is expected that it will be operated most of the time with an input of 500 kw. The maximum capacity of enamel ware production is 3000 pounds of material an hour and the furnace can take care of 2430 square feet of ware in that time.

The present plans call for operating procedure to consist of placing the ware on the table top by hand and as the chamber will make a complete revolution in 24 minutes, there will be 21 minutes in which to unload the table. It is expected that labor cost can be materially reduced as ordinary labor can be used for all the work and the men will be able to keep busy all the time loading and unloading ware. The racks will be of very light material as they are placed on a level table and are not handled with force. They are supported along their full length and will accordingly not sag. The furnace can be operated at any desired temperature in the enamel range up to 1850° for ground coat.

It will be very interesting to see the results obtained from this installation and to study the possibilities of this method of operation in large enamel shops.

The information set forth in the foregoing covers the principal developments of the year of 1921. The notable advances that have been made foretell greater developments in the years to come and we may look cheerfully to the future for far-reaching advances in this phase of the Ceramic Art.

Discussion

Mr. LINDEMANN:—Mr. Chairman, I visited the St. Louis Brass Works last night, and watched their electric furnace in operation. Mr. Mehling made the statement then that they could turn out twice as much work as with a coal furnace, but I can not understand why, if you maintain the same temperatures, there should be any difference in the production of one furnace against another. There are furnaces built today which can, without any question, maintain a temperature of 1600° to 1700°F in continuous operation, putting in successive loads as fast as is possible. Why can't you turn out as much work there as in an electric furnace?

Mr. HAIN:—Here is an illustration of an enameling furnace handling hollow ware. The resistor is near the work and very rapid action results from that resistor and very delicate temperature control is obtainable.

It has been found with electric furnaces not only of this type but electric furnaces for steel heat treating and for melting brass and non-ferrous metals, as well as arc type furnaces in melting down steels, that electric heat was very much more rapid than that from other types of fuel. That has been explained by the fact that most all of the heat is transferred from

the ribbons by radiation rather than by convection gases, radiation being a rapid method of transference of heat. In this type of furnace, we have estimated that probably 85 per cent of the energy is transferred from the element, which generates the heat, directly into the work by radiation and the balance by convection. That is the explanation of the speed which you get out of electric furnaces. It is not only notable in high temperature furnaces of this kind but also notable in japanning at low temperature, and it is universal in electric furnaces. That is the explanation that has been given for it.

Mr. LINDEMANN:—The fact that it is generally conceded does not answer my question.

Mr. HAIN:—I have attempted to explain that the fact that the energy is obtained by radiation, rather than convection, is the answer.

Mr. JAEGER:—Mr. Chairman, from observing operations on both types of furnaces, I believe that question can be answered by citing a simple example. In putting a heavy casting into an ordinary muffle type furnace anyone who has seen the operation will recall that the bottom and side tile get dark, which would not be the case in an electric-heated furnace. The electric-heated resistors will not cool off as they are constantly giving out energy.

CHAIRMAN POSTE:—In other words, Mr. Lindemann's hypothesis, that you do maintain the same temperature, is not realized.

Mr. LINDEMANN:—Mr. Poste, we observed last night, that with twenty-five ordinary electric reflectors, the recording pyrometer showed that when first loaded the furnace temperature dropped one hundred and fifty degrees. I can show you coal-fired furnaces taking eight hundred pounds of cast iron where the furnace temperature would not drop over forty degrees.

CHAIRMAN POSTE:—What are the details as to the location of the end of the thermocouple in two places?

Mr. LINDEMANN:—The end of the thermocouple was within a few inches of the resistor ribbon, and in the coal-fired furnace it was placed in the rear end of the furnace about half way up and projected six inches into the furnace, which is eleven feet in length.

Mr. SWEELY:—I might be able to help out a little. It is a question not only of location of installation but also of the type of installation. I would like to ask Mr. Lindemann if his thermocouple is enclosed in a tube?

Mr. LINDEMANN:—No, it extends through a tube, the couple itself being exposed.

Mr. SWEELY:—We have four coal-fired furnaces and this electric furnace as shown on the back of this sheet, which gives us the opportunity to compare the two furnaces. We have put couples into the back of our

coal-fired muffle furnaces, which are the standard type, the old type. I am not speaking of the carbon muffle or the gas-fired or oil-fired type, but the old fashioned coal-fired muffle furnace. When putting a load in we get the same temperature drop in introducing the charge as we get in the electric furnace. However, it is not a question of drop in temperature of the furnace but a chilling of the air within the furnace. Convection plays a large part in the heating of the ware. As soon as the cold ware is introduced into your furnace, a circulation of air is started. If you chill the air it will fall, the hot air will rise and, naturally, the air is chilled in the vicinity of the couple. The result is there will be a sharp drop when introducing the ware.

That has been our experience with either type of furnace, but the load introduced in the electric furnace is larger, and the heat is there. With the coal-fired muffle we are using, the furnace will not maintain its heat with a heavy charge, due to the fact that the muffle tile will not conduct heat fast enough to the muffle chamber. That, I think, is the explanation of the difference.

Mr. KALLSTEDT:—I would like to ask how long Mr. Sweely figures it takes to heat up this larger furnace from a cold start?

Mr. SWEELY:—We have never allowed the furnace to cool off. We heated it up once. The first time it was heated up, we had the condition of wet brickwork and all that sort of thing to contend with, which is not a fair test. Any furnace will heat up slowly when first built.

The best idea I can give of the way the furnace heats is when the furnace is shut off. We shut the furnace off on Sunday morning at six o'clock, as we do not operate on Sunday, and start the following morning at about three, and the temperature will be from 1000° to 1200°F when we turn the current on, and it will require about two hours to bring the furnace up to heat, but the furnace will have to be kept on an hour or two longer to get maximum production. It is a case of storing a certain amount of heat in the brickwork.

Mr. KALLSTEDT:—I can readily see that the radiation loss would not amount to a great deal, because the furnace takes care of that. However, if operating conditions were such that you had to shut down your furnace for a week, would it not pay to keep the furnace hot? I have seen intermittent gas-fired furnaces ready to operate at 1750°F from a starting temperature of 600°F in forty-five minutes. This I believe would be impossible with this furnace.

Mr. SWEELY:—I do not think it would pay to keep it hot. We do not keep it hot over Sunday, although the furnace would only be taking current about one-fifth of the time.

Mr. RIESS:—I visited the St. Louis Brass Co. last night, and was advised

it took about twelve hours to heat that furnace from a cold to a working temperature.

Mr. STALEY:—The electric furnace we have—we use about the same size—takes us about twelve hours, and you get exactly the same amount of current that it takes to maintain the furnace. We maintain our furnace with about seventy kw. per hour. After we get it up, it takes twelve hours of seventy kw. to keep it up.

Mr. LINDEMANN:—The reason I asked the question was to start a discussion, because I had in mind that, possibly due to additional expense of installation and the expense of operation, it probably was a fact that anyone who owns an electric furnace would operate the same more carefully and drive his men to get more production than under other circumstances.

We had a similar experience some years ago on japanning, where the question of installing electric ovens came up. At that time, taking into consideration what was necessary to operate the electric japanning oven, we applied the same conditions to a gas oven, and increased our production nearly fifty per cent. I believe similar conditions account for some of the advantages in the operation of electric furnaces in comparison with coal-fired muffle where precautions are not taken. I would like to ask Mr. Sweely whether he has any particular reference to that subject?

Mr. SWEELY:—I should not want anyone to get the impression that I am selling electric furnaces or that we believe an electric furnace is the only thing for enameling. We have put this furnace in, and so far we have no cause to regret it.

As to getting down to actual cost, the furnace was started in December and, like many plants that are making money, we have not worried about the cost. The figures presented in this paper are approximately correct. I have not checked them over personally, but that will probably be done sooner or later in the plant. I think there are a number of furnaces that are very good.

I would like to call the attention of the Ceramic Society to a furnace that is in operation in the Chicago district—a gas-fired furnace without a muffle, which is giving good results. I have seen both of them in operation and they are doing good work. Whether they are doing poorer work than the electric furnace, I do not know.

CHAIRMAN POSTE:—Is there anything else bearing immediately on the paper that has just been presented?

Mr. RIESS:—I would like to ask Mr. Sweely whether he had that electric furnace in operation long enough to make comparative costs.

Mr. SWEELY:—We have not as yet. That is the point I was trying to make.

CHAIRMAN POSTE:—Has anyone any data on that point?

Mr. MAHONEY:—I would like to ask Mr. Sweely if he has experimented with leaving that furnace run over Sunday and then cutting it down and turning it on at three o'clock to make a comparison as to whether it was cheaper to keep the furnace at heat or let it cool down.

Mr. SWEELY:—The plant engineer and myself have been having a little controversy on what is the best policy. I wanted the furnace in full heat on Monday morning, but as yet we have not settled the matter.

Mr. WENNING:—The cost of operation of an electric furnace in one stove factory runs about three hundred dollars a month. In Canada they are running seven furnaces at about half the cost.

HEAT TRANSMISSION, WITH SPECIAL REFERENCE TO THE STOKER FIRED BOILER[1]

By R. M. Howe and S. M. Phelps[2]

ABSTRACT

It has been demonstrated that the temperature within the brickwork depends to a very large extent upon the pressure conditions within the furnace. When the gases are under pressure they penetrate the brickwork, impart their heat, and raise the temperature above that which would result from simple thermal conductivity. When the gases are under draft, cold air is drawn through the brickwork into the furnace and it exerts a cooling effect. Spalling is therefore associated with furnace pressure; when positive, spalling is greater than when negative. This is due to the fact that spalling is a function of vitrification, which in turn is a function of temperature. It s believed that these results may explain the lack of concordance in those pertaining to thermal conductivity. They probably represent heat transmission in a number of cases and are therefore higher or lower than conductivity according to the direction of the gas flow.

When high grade coal was available at a low cost there was little necessity for the study of furnace efficiency. Today this subject is being given serious consideration wherever coal is burned. The forced draft automatic stoker is a logical outgrowth of the effort to burn this fuel more economically. With its application the efficiency obtained with bituminous coal has been increased from 50 to 65 per cent, while that obtained with semi-anthracite has increased from 70 to 75 per cent. Some coals that could not be used in hand-fired furnaces are now being utilized with great economy.

The importance of greater efficiency may be illustrated by the fact that a medium grade coal (11,000 B.t.u.'s) burned with an efficiency of 65 per cent is equivalent to a high grade coal (14,500 B.t.u.'s) burned with an efficiency of only 50 per cent. A low grade coal (9,000 B.t.u.'s) would have a similar value if burned at an efficiency of 80 per cent. The following table shows the relative values of different grades of coal when burned under different degrees of efficiency for the evaporation of water in boilers. These figures are based on evaporation from, and at, 212°F.

Table I

	50% Efficiency		65% Efficiency		80% Efficiency	
B.t.u. per pound coal	Evaporation per pound coal	Pounds coal per h.p. per hour	Evaporation per pound coal	Pounds coal per h.p. per hour	Evaporation per pound coal	Pounds coal per h.p. per hour
7500	3.8	9.0	5.0	6.8	6.2	5.5
9500	4.9	7.0	6.3	5.4	7.8	4.4
12500	6.4	5.3	8.4	4.1	10.3	3.3
14500	7.5	4.6	9.7	3.5	12.0	2.8

[1] A contribution from the Industrial Fellowship of the Refractories Manufacturers Association, Mellon Institute of Industrial Research, University of Pittsburgh, Pittsburgh, Pa.

[2] Read before Refractories Division, St. Louis Meeting, Feb. 28, 1922.

It has been noted, however, that the service obtained from the refractories is usually shorter when used with low grade fuel burned by forced draft. This decreased service is not due to higher furnace temperatures nor to increased slag action. The refractories do have a higher tendency to spall. It was suggested that this condition might be due to changes in furnace pressure when automatic stokers replaced hand firing.[1] Accordingly, a study was made of the influence of furnace gas pressure upon heat penetration.

Fire clay tile were made so that temperature readings could be obtained at several distances from the hotter surface. These tile were placed in the door of a furnace, laid up with fire clay, and heated under the condition indicated below. The temperature measurements were checked every hour and finally recorded when equilibrium was established. The position of the tile was not disturbed until the tests were complete.

TABLE II

Furnace Temperature	1340°C	1340°C	1340°C	1220°C	1220°C	1220°C
Pressure of furnace gases (inches of water)	+1.00	+.05	−.30	+.95	+.05	−.30
Temp. of fire brick 1/2 in. from hot surface	1305	1265	1105	1105	1075	900
" " " 1 in.	1270	1210	1020	1035	965	800
" " " 2 in.	1125	1040	800	900	770	620
" " " 3 in.	1040	950	720	800	660	490
" " " 4 in.	845	745	515	665	510	355

Upon examining these data, it becomes evident that heat penetration depends very largely upon the pressure of the furnace gases. It is not only a function of the thermal conductivity of the brick, but also depends upon its permeability. The temperatures recorded at a pressure of +.05 inch of water probably approximate equilibrium conditions for a tile of that character, thickness, and conductivity. The temperatures recorded at a pressure of +1.00 inch of water indicate the extent to which the permeating gases imparted heat to the brickwork. The temperatures recorded under a draft of .30 inch of water show the cooling effect of cold air that was drawn from the room, through the brickwork, and into the furnace.

Consequently, the temperature within the brickwork of a furnace will be several hundred degrees higher when operated under pressure than when operated under draft conditions. Pressure, therefore, accelerates vitrification, which is a function of temperature and which progresses rapidly in first-quality fire brick at about 1350°C. As fire brick vitrify they become less resistant to temperature change and spall more rapidly. In view of these facts a higher tendency to spall is the natural and unavoidable

[1] This suggestion was made by Mr. J. E. Harlow, Chief Engineer, M. H. Detrick Co., whose co-operation is hereby acknowledged.

result of changing from draft to pressure, reducing the draft, or increasing the pressure of the furnace gases.

In obtaining the experimental data under discussion, it was necessary to lay up the tile in fire clay so that the proper draft and pressure could be obtained under laboratory conditions. It is obvious, however, that the influence of these conditions would be far greater were the fire clay joint omitted, as is sometimes the case in actual service. This being the case, it might be beneficial to omit the joint where the furnace is operated under draft conditions. On the other hand, it might be possible to minimize the effect of pressure in producing a high temperature within the brickwork by using a dense burning material in the joints. Care should be exercised, however, in selecting bonds of this type for they are very often of low refractoriness and consequently leave the joint open as they melt and run.

The joint should never be greater than $^1/_{16}$ inch in thickness.

A thin wash (less than $^1/_4$ inch) of dense burning cement can also be applied with advantage to the entire furnace lining. When this vitrifies or melts at furnace temperatures it retards gas penetration and in that way decreases spalling by virtue of a lower temperature within the brickwork. While joints must always be made as thin as possible, these washes may be applied more thickly; softening of a joint may cause the collapse of the brickwork while a wash supports nothing but its own weight. The deposition of an easily fusible ash produces the same effect as may be secured by the application of a wash but, of course, is accidental and cannot be relied upon.

The application of these results is not limited, however, to this particular problem. They have a direct bearing upon the study of thermal conductivity and upon the application of the load test.

The heat transmitted through a refractory is not necessarily a measurement of its thermal conductivity. It depends upon at least two factors—the thermal conductivity of the material itself and the penetration of hot or cold gases. Heat transmission and thermal conductivity equalize when there is no circulation of gas within the material. Heat transmission is greater or less than thermal conductivity when hot or cold air is drawn through the specimen under consideration. The type of furnace used will effect thermal conductivity results and this fact may explain the lack of concordance of those on record. An electrically heated furnace should reduce errors in thermal conductivity measurements to a minimum, for no gases are in rapid motion; gas-fired furnaces are usually under high pressure or draft, depending upon whether a blower or stack is relied upon to supply the air for combustion.

These results also limit the application of the load test. They demonstrate that the drop in temperature is very sudden in uninsulated walls.

Consequently, the major portion of a fire brick will be at a sufficiently low temperature to carry the load of the average installation. The load test is, therefore, directly applicable only to muffles and cases where insulation is applied.

They also throw an important light upon the action of slag on fire brick. From these data, it is evident that the slag will penetrate only to a slight extent before it becomes chilled. Before going further it must dissolve the brickwork, after which there is a temperature readjustment allowing further penetration. The action is, therefore, primarily a junction of the fluxing power of a given slag. These conditions must not be overlooked in the future development of a slag test, as they have in the past. Results obtained by heating a brick throughout and treating with a small quantity of slag have no practical application, for they measure penetration and not the chemical action of the slag. Further studies of heat penetration are now under way and additional data have already been obtained. These data, however, are not applicable to the present discussion.

MELLON INSTITUTE OF INDUSTRIAL RESEARCH
UNIVERSITY OF PITTSBURGH
PITTSBURGH, PA.

Discussions

BY J. E. HARLOW:—Our product consists chiefly of a flat suspended fire clay tile arch. This arch is used as a roof over the enclosure where all kinds of fuel are burned and where all kinds of hot gases travel. Its chief function, of course, is to reflect heat, thus assisting and maintaining combustion. The temperatures reached vary from 1100°C to 1400°C.

The chief requirements of a flat suspended arch are proper position in the furnace, freedom to expand and contract without stress or strain, and a good refractory.

The requirements of a refractory for a suspended arch of the best design are high fusing temperature, high resistance to corrosion, and abrasion from high temperature gases and high resistance to spalling.

Most hand-made tile have sufficiently high fusing temperature to resist the temperatures encountered in boiler furnaces. There are furnaces, where the temperature is higher and where the heat is termed "soaking heat," that require more special attention to fusing temperature. These are found chiefly in the metallurgical processes where high temperature and slow gas velocity present a different refractory problem.

Resistance of refractory to corrosion and abrasion of gases is a more serious problem, especially with fuels of high ash content or fuels containing a basic compound.

Resistance to spalling is the most serious problem. Fire clay manufacturers can assist as far as the problem of proper mixture of flint, plastic

and calcined clay is concerned; also in the degree of burn. But the arch designer can assist very materially by making a shape easily manufactured and free from entrant angles.

These requirements are obvious, but as the problem becomes clearer to our minds, the action of heat within the tile becomes a question. Observation and analysis have shown that spalling can be reduced by exposing only one plane or slightly curved surface to the heat. Success with this idea leads by analogy to the prevention of heat penetration into the joints between the surfaces of the tile.

This is a difficult matter for the reason that fire clay tile manufacturers do not always succeed in making tile with plane surfaces and square angles and the action of fire clay used as mortar or grout is very uncertain. It may be solved by some high temperature cement coating, and it may be solved by the accidental presence of a low fusible ash. The writer is inclined to the use of common salt, but is well aware of the objections and makes use of that in a very limited way, dictated, of course, by observation of hundreds of various furnaces in actual operation. The present paper confirms our reasoning in this problem, and suggests many other problems. One of them is the depth of tile to be used in a suspended arch.

M. H. Detrick Company
Chicago, Illinois

By P. Nicholls:—Most engineers concerned with heat transmission have recognized that leakage of air through a material would affect its apparent conductivity, and consequently also the temperatures through its section, but the authors are to be congratulated on being the first to demonstrate experimentally what may be the order of value of such changes.

It is unfortunate that the paper does not give fuller details of the apparatus used, and in particular of the tile blocks themselves. Were, for instance, these blocks four inches thick, so that the 4-inch temperatures are those at the surface? If so, such temperatures would give some relative idea at least of the quantity of heat transmitted if the air temperature near the surface were known, and if the face was not too much shrouded by other parts of the apparatus.

Were the holes for the thermocouples parallel or at right angles to the face of the tile, and were proper precautions taken that the air was not short-circuited by such holes, as this might materially affect the temperatures indicated by the thermocouples? Since the same blocks were used throughout the tests, was there any surface change that would tend to clog up the pores and thus successively reduce their porosity?

In lack of a knowledge of the value of the heat flow it is not worth while attempting to form any idea of the amount of gas or air passing through the tile, but some interesting confirmation of the effect of leakage on the

temperatures can be made from a study of curves representing the results, which are plotted on Fig. 1.

Curves 1, 2 and 3 are the three where the furnace temperature was 1340°C, and 4, 5 and 6 where it was 1220°C. The dotted parts of the curves are on the assumption that the furnace temperatures existed about

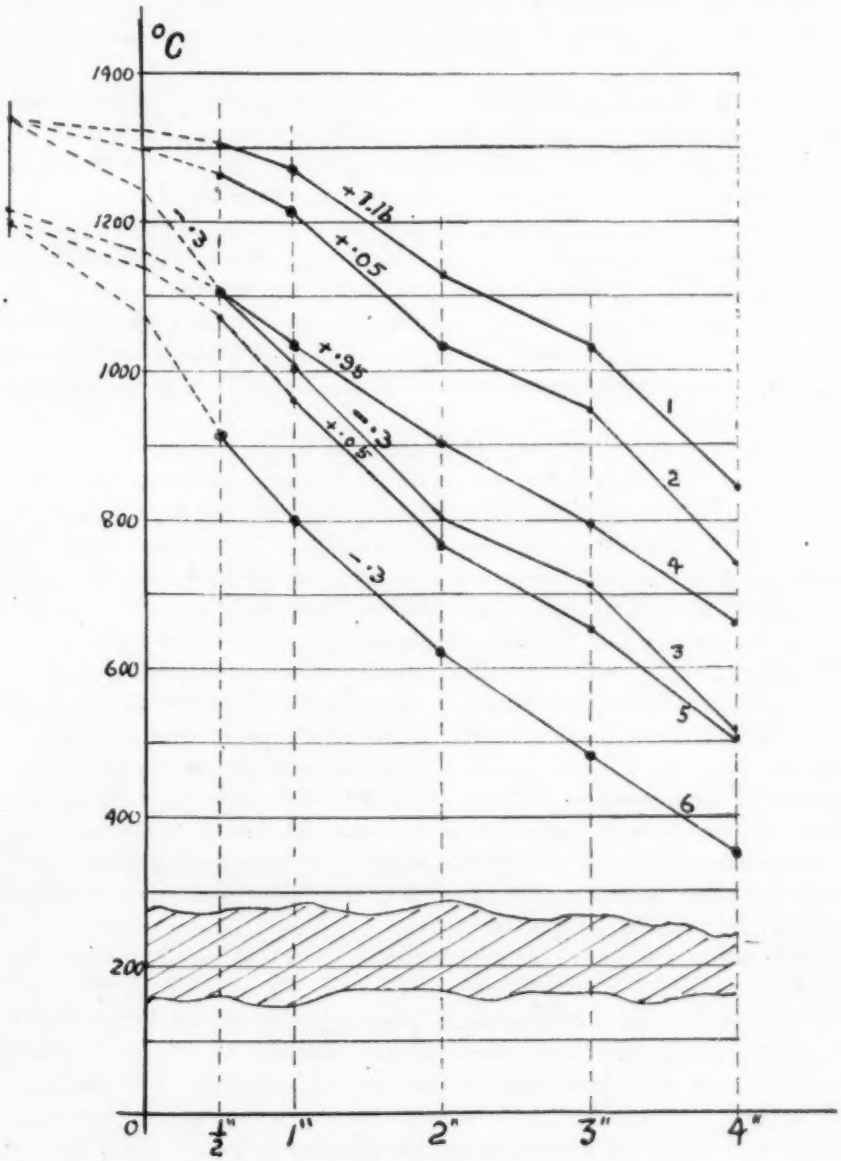

FIG. 1.

one inch from the inner face of the wall and are, of course, uncertain as to their correctness.

It would appear that possibly one or both of the temperatures at the 2-inch and 3-inch points are in error. Such temperatures are difficult to obtain accurately—especially with holes at right angles to the face, that is in line with the direction of heat flow—due to the disturbing effect of the holes themselves and to the higher conductivity of the metal of the couples.

Assuming that gas or air passes through the wall, what will be its effect on the temperature? Consider the case of the hot gases passing from the furnace to the outer face. It can be assumed that the rate of flow is constant when practically constant conditions have been established. Since the gas is cooled down in passing through, the only way it can have parted with its heat is to have given it up to the material, which in turn transmits it to the surface. Before constant conditions are reached, some of this heat will also be used to raise the temperature through the wall, but finally the heat taken up from the gas by any small piece of material will become constant, and be equal to the increase in the rate of flow in the material at that point.

The general effect of the passage of the gas is to add through the material what is equivalent to a source of heat supply equivalent in action to generation of heat at all points, and this action is superimposed algebraically on the transfer by direct conduction from the inner hot surface. Also the temperature of the gas at any point must always be greater than the material in contact with it, though this difference may be small.

The general effect on the temperature curve can be seen by a simple consideration. Fig. 2 represents any small section, at right angles to the direction of heat and gas flow, and of thickness AB. Divide this equally at C. Then the heat flowing across CC' is greater than that across AA' by the quantity of heat absorbed from the gas by the thickness AC. Similarly, the flow across BB' is greater than that across CC'. Assuming that the conductivity coefficient of the material does not decrease with temperature increase, it follows that the drop in temperature from C to B is greater than that from A to B, and thus the temperature curve would be concave toward the temperature axis.

Similarly in the case of air passing from the outside to the furnace, the temperature curve would be convex.

In addition to this, it has been pretty well established that the conductivity of ceramic materials increases with the temperature, which will again bow up the temperature curve, so that with air inleakage, the departure of the curve from a straight line will be the resultant of these two tendencies.

Again, because the outer surface temperature is higher when the hot gases pass outward than it would be if there were no gas transfer, therefore

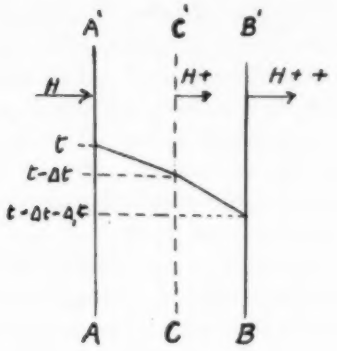
A'
C'
B'
H
H+
H+ +
t
t-Δt
t-Δt-Δ₁t
A
C
B

Fig. 2

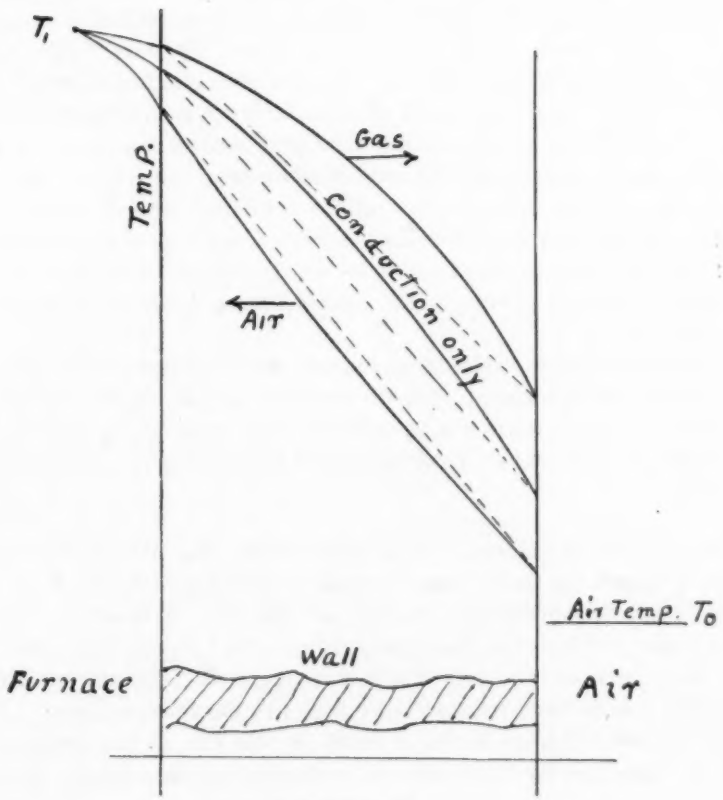
T₁
Temp.
Gas
Conduction only
Air
Air Temp. T₀
Wall
Furnace
Air

Fig. 3

there will be a smaller quantity of heat transferred from the furnace by direct conduction. Similarly with passage of air inward the flow of heat by direct conduction only will be greater. This argument should strictly be applied to the rate of change at the inner surface, but the same reasoning still applies, and more so, in as far as the gas or air temperatures, respectively, differ from that of the material. These tendencies in the two cases are in opposite directions and would counterbalance each other as far as general comparisons go.

Fig. 3 shows these expected curves plotted for shape only, and it is apparent that those in Fig. 1 as found by the authors exhibit the same tendency, though there is not as much curvature distinction between that for 1 inch and .05 inch pressure, as between the .05 inch and the −.3 inch.

Fig. 1, showing the results of the tests, gives a comparatively large difference between the temperatures at each surface for gas and air leakage. It is to be expected that the method of test accentuates this greatly compared with what would be found in actual furnaces. The leakage must have been comparatively high, and possibly the heat reserve in the furnace was comparatively small and the velocity of the gases over the surface low, so that the inleakage of air produced at the inner surface a large increase in the air film thermal resistance.

Probably more detailed investigations into and determination of the physical actions causing spalling are needed before it is safe to make assured deductions, as it would appear to be a choice between higher temperatures with smaller rates of change in the case of outward flow, and the reverse for inward flow.

If the inward flow is desired, the remedy would seem to be to connect a space behind the brickwork with the pressure supply, and it should thus be possible to maintain a greater pressure than that above the fuel bed. This should be particularly easily arranged for in the case of the majority of arches.

REPLY by R. M. HOWE:—It is unfortunate that Mr. Nicholls should be forced to ask for information regarding testing details, but these were omitted from this preliminary report for the sake of brevity. The tile were 9 inches in thickness, but temperature observations were not made in the cooler half as they were too low to affect the properties of the tile. The thermocouple holes were at right angles to the furnace lining. There was no apparent change in the porosity of the tile at the temperatures involved, these having been selected with this point in mind. It might be stated also that the 1200° C readings were made first.

Mr. Nicholls' discussion of curves 1 and 3 is particularly interesting and encouraging to the writer, who has read so many contradictory reports

on the thermal conductivity of refractories. Thermal conductivity results obtained in well planned investigations often show variations as great as 100 per cent and rarely show a definite tendency that may be expressed graphically. While several of the points in Fig. 1. are obviously incorrect the general tendencies of these curves are similar to those in Fig. 3.

It is possible that Mr. Nicholls' suggestion regarding a pressure reservoir back of the brickwork might be applied to prevent the passage of gas from the furnace into the tile.

We are not willing to modify our original statement regarding the effect of furnace pressure upon spalling for the chain of evidence is too complete. The temperature within the brickwork of furnaces operating under pressure is greater than with those operating under draft. Vitrification is a function of temperature. Spalling is accelerated by vitrification. Therefore, it is obvious that spalling will be more pronounced where the furnace is being operated under pressure, and the usual heating and cooling takes place.

The opinions expressed by J. E. Harlow are in general agreement with those which have been formed by the writer.

In view of the results that were obtained by this very elementary study, additional tests involving tile of different thicknesses are now under way.

THE FIELD OF PORCELAIN GLAZES MATURING BETWEEN CONES 17 AND 20[1]

By Robert Twells, Jr.[2]

ABSTRACT

Field Covered.—A typical porcelain glaze formula:

$$\left.\begin{matrix}0.3\ K_2O\\0.7\ CaO\end{matrix}\right\} \times Al_2O_3\ Y\ SiO_2$$

was used. The RO was held constant, the Al_2O_3 was varied between 0.8 and 1.6 equivalents, and the SiO_2 between 6 and 16 equivalents.

Firing Test.—The glazes were applied to green porcelain dises and fired to cone 17 $^3/_4$ down, and cones, 18, 19, and 20 down in commercial kilns.

Representation of Results.—The glazes are plotted according to batch weights and empirical formula. The diagrams show the location of the best glazes at each temperature better than would statements of limits.

Best Compositions.—Under conditions similar to those used, the best glazes for temperatures between cones 17 and 20 have the following range of composition:

Clay	21.9% to 27.2%
Flint	40.8% to 51.8%
Feldspar	17.2% to 23.6%
Whiting	7.2% to 10.0%

Introduction

The field of porcelain glazes maturing between cones 9 and 11 has been carefully studied by several investigators,[3] and its characteristics are well known. Systematic information in regard to porcelain glazes maturing above cone 11 has been somewhat meagre. Recently, however, the Bureau of Standards published an article on "High Fire Porcelain Glazes"[4] covering the field maturing between cones 10 and 16. Above cone 16 there is still a lack of published information. Several months before the publication of the work of the Bureau of Standards, the writer had made a short study of some porcelain glazes maturing between cones 17 and 20. The methods employed were similar in several respects to those used by Sortwell at the Bureau of Standards; although in this case the firing was done in commercial kilns with a longer firing period. The object of this article is to publish some systematic information in regard to some porcelain glazes maturing at temperatures even higher than those studied by the Bureau of Standards. The writer recognizes the fact that similar results are not likely to be obtained except by the use of similar methods, raw materials, and body.

[1] Research laboratories, Champion Porcelain Company and Jeffery-Dewitt Insulator Company.

[2] Read before Whiteware Division, St. Louis Meeting, Feb. 28, 1922.

[3] R. T. Stull, *Trans. Am. Ceram. Soc.*, **14**, 62–67 (1912). R. T. Stull, and W. L. Howat, *Ibid.*, **16**, 454–460 (1914).

[4] H. H. Sortwell, *Jour. Am. Ceram. Soc.*, **4**, 718–730 (1921).

Compositions Studied

The compositions of the glazes were based on the empirical formula:

$$\left.\begin{matrix}0.3\ K_2O \\ 0.7\ CaO\end{matrix}\right\} \times Al_2O_3\ Y\ SiO_2.$$

The RO members were held constant; the alumina was varied between 0.8 and 1.6 equivalents; the silica was varied between 6.0 and 1.6 equivalents. Fig. 1 shows the molecular variation of the alumina and silica in the glazes. Fig. 2 shows the batch weights of the glazes as calculated in percentages of clay, flint, and fluxes. The fluxes consist of feldspar and whiting in the proportion of 167 parts feldspar to 70 parts of whiting. As originally laid out the field consisted of the glazes numbered from 1 to 16. These were made by cross-blending numbers 1, 4, 13, and 16. A preliminary test showed that this series did not include as much of the area of bright glazes as was desired. Glazes 17 to 23 were included.

These were made by cross-blending numbers 15, 17, 21, and 23.

TABLE I

BATCH WEIGHTS OF THE CORNER GLAZES

Number	1	4	13	15	16	17	21	23
Feldspar	13.2%	14.1%	18.4%	19.6%	20.2%	20.9%	27.3%	30.0%
Whiting	5.5	9.5	7.7	8.2	8.5	8.8	11.4	12.5
Clay	26.6	15.3	36.95	27.2	21.9	16.3	37.8	23.1
Flint	54.7	64.7	36.95	45.0	49.4	54.0	23.5	34.4
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

SOURCES OF RAW MATERIALS

Feldspar—Maine Feldspar Co., Shipping point, Auburn, Maine.
Whiting —Solvay Process Co., Delray, Mich.
Clay —Edgar Plastic Kaolin Co., Shipping point, Edgar, Fla.
Flint —Penna. Pulverizing Co., Shipping point, Hancock, W. Va.

Procedure

The corner glazes already given were weighed out, and ground wet for four hours in small ball mills. The cross-blending to produce the intermediate glazes was performed by mixing the corner glazes wet in the proper proportions as determined by their relative molecular weights and specific gravities. Care was taken to obtain thorough mixing.

The glazes were applied on green porcelain discs $1^1/_4$ inches in diameter and $^1/_2$ inch thick. The discs were air dried, but were dipped in water before being dipped in the glaze. The composition of the body was as follows:

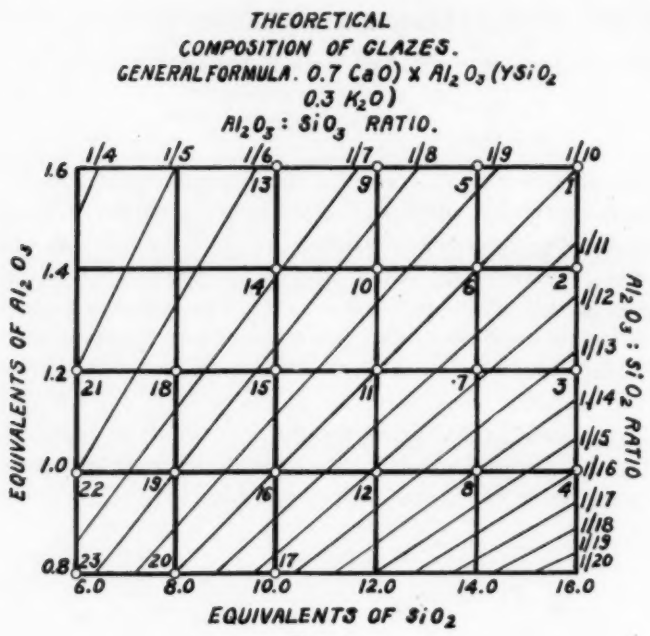
THEORETICAL
COMPOSITION OF GLAZES.
GENERAL FORMULA. 0.7 CaO) x Al2O3 (YSiO2
0.3 K2O)
Al2O3 : SiO3 RATIO.
EQUIVALENTS OF Al2O3
EQUIVALENTS OF SiO2
Al2O3 : SiO2 RATIO
1/4
1/5
1/6
1/7
1/8
1/9
1/10
1/11
1/12
1/13
1/14
1/15
1/16
1/17
1/18
1/19
1/20
1.6
1.4
1.2
1.0
0.8
6.0
8.0
10.0
12.0
14.0
16.0

FIG. 1.

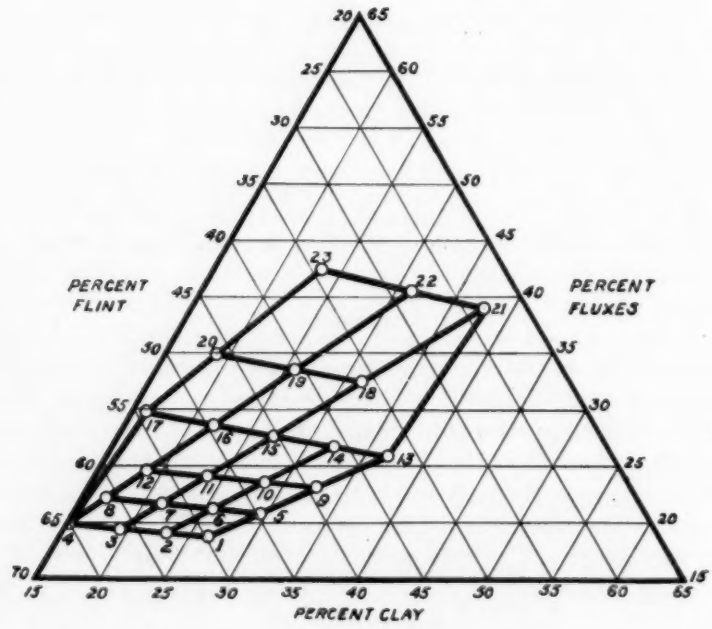
PERCENT FLINT
PERCENT FLUXES
PERCENT CLAY

FIG. 2.

English Ball Clay (M. and M.)	5.0%
North Carolina Kaolin (Harris Spruce Pine)	12.0
Florida Kaolin	8.0
English China Clay (M. W. M. No. 2)	30.0
Flint	30.0
Feldspar	15.0
	100.0%

This body was vitreous from cone 17 to cone 19, but overfired at cone 20 with a longer firing period.

In each sagger were placed three cones of proper number. Around these were arranged 23 of the discs, each coated with one of the glazes. Part of the saggers were fired in a Dressler tunnel kiln to temperatures ranging between cone $17^3/_4$ and cone 19 down. The maximum heat was reached in approximately 31 hours. Another sagger was fired in a large periodic kiln to cone 20 down. It reached this temperature in approximately 52 hours.

Results at Cone $17^3/_4$

Fine crazing occurs with a theoretical alumina: silica ratio of 1:12 or less. (Figs. 3 and 4.) This is in the region of high flint. Coarse crazing occurs with a theoretical alumina : silica ratio of 1:5 for 6 equivalents of silica. This is in the region of low flint, high clay and high fluxes. The area of smooth glazes is large. Its limits are best understood by reference to the diagrams. Between the glazes termed "Smooth Transparent" and "Smooth Opaque" there is no distinct dividing line. The opacity increases gradually in the general direction of the flint. The opaque glazes might possibly be called semi-mats, but since they become transparent when fired to a higher temperature, the term "opaque" seems more appropriate. Glaze No. 13, however, is a true aluminous mat. It has a theoretical alumina: silica ratio of 1:625 for 10 equivalents of silica. This glaze is located in the region of high clay. The glazes high in fluxes tend to be seedy due to entrapped bubbles in the glaze.

Results at Cone 18 Down

The area of fine crazing is reduced at this temperature. The theoretical alumina: silica ratio of the fine-crazed glazes is 1:14 or less. (Figs. 5 and 6.) The area of coarse crazing is increased at this temperature to include No. 22, which suffered delayed crazing after about 8 months in the air. The other characteristics are similar to those described for cone $17^3/_4$.

Results at Cone 19 Down

The area of fine crazing is similar to that at cone 18 down. (Figs. 7 and 8.) It is, however, extended enough to include No. 12 with theoretical

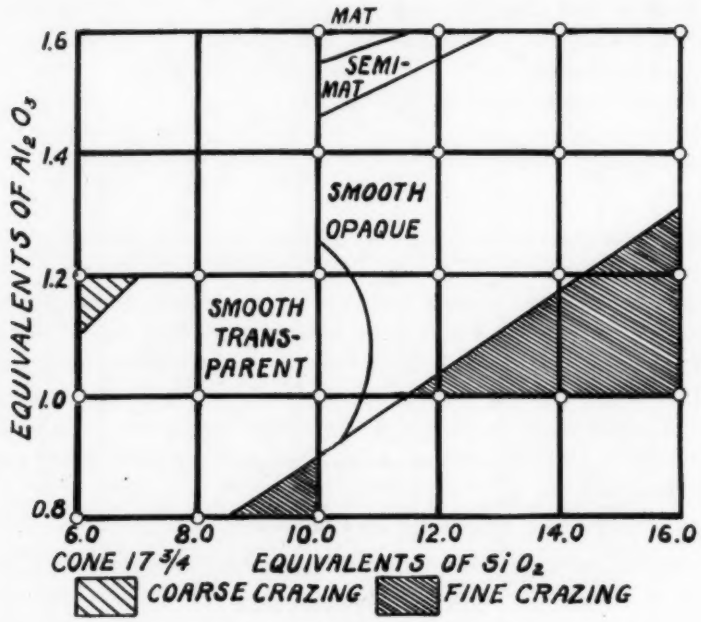
MAT
SEMI-MAT
SMOOTH OPAQUE
SMOOTH TRANS-PARENT
EQUIVALENTS OF Al_2O_3
1.6
1.4
1.2
1.0
0.8
6.0
8.0
10.0
12.0
14.0
16.0
CONE 17 3/4
EQUIVALENTS OF SiO_2
COARSE CRAZING
FINE CRAZING

FIG. 3.

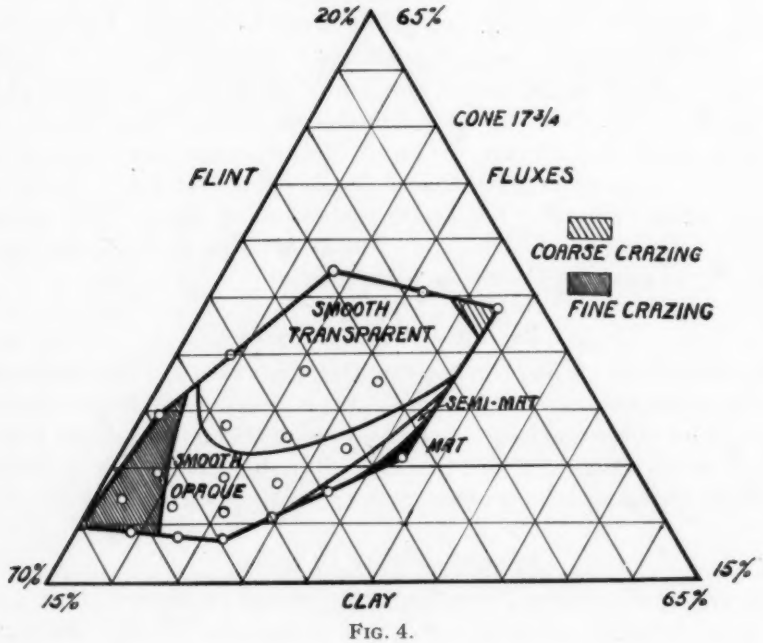
20%
65%
CONE 17 3/4
FLINT
FLUXES
COARSE CRAZING
FINE CRAZING
SMOOTH TRANSPARENT
SEMI-MAT
MAT
SMOOTH OPAQUE
70%
15%
CLAY
15%
65%

FIG. 4.

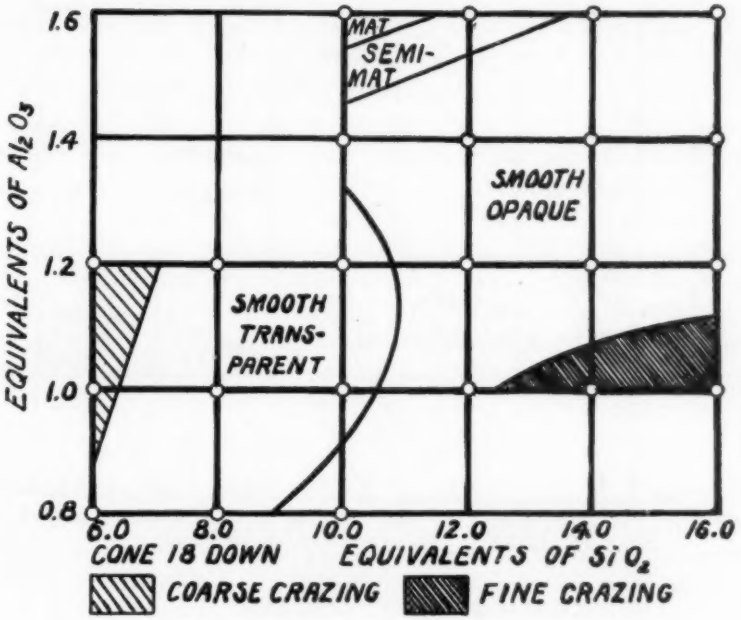
1.6
1.4
1.2
1.0
0.8
EQUIVALENTS OF Al_2O_3
MAT
SEMI-MAT
SMOOTH OPAQUE
SMOOTH TRANS-PARENT
6.0
8.0
10.0
12.0
14.0
16.0
CONE 18 DOWN
EQUIVALENTS OF SiO_2
COARSE CRAZING
FINE CRAZING

FIG. 5.

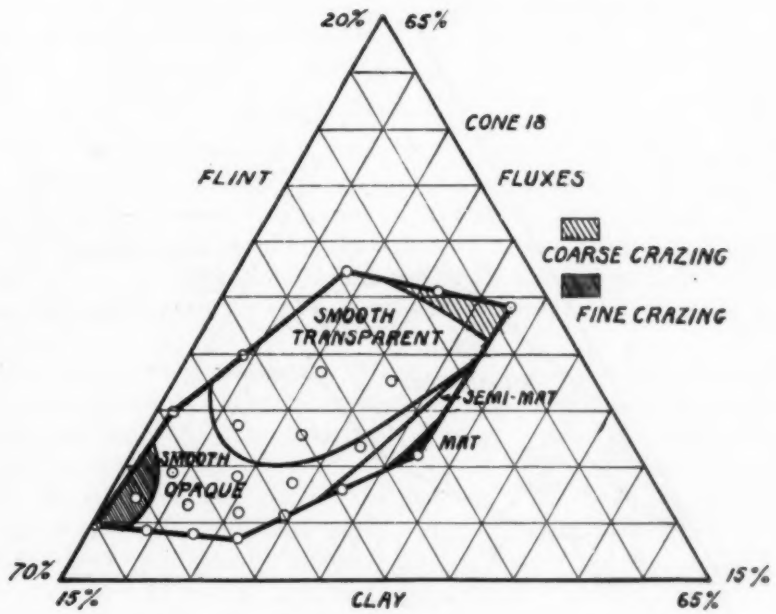
20%
65%
CONE 18
FLINT
FLUXES
COARSE CRAZING
FINE CRAZING
SMOOTH TRANSPARENT
SEMI-MAT
MAT
SMOOTH OPAQUE
70%
15%
CLAY
15%
65%

FIG. 6.

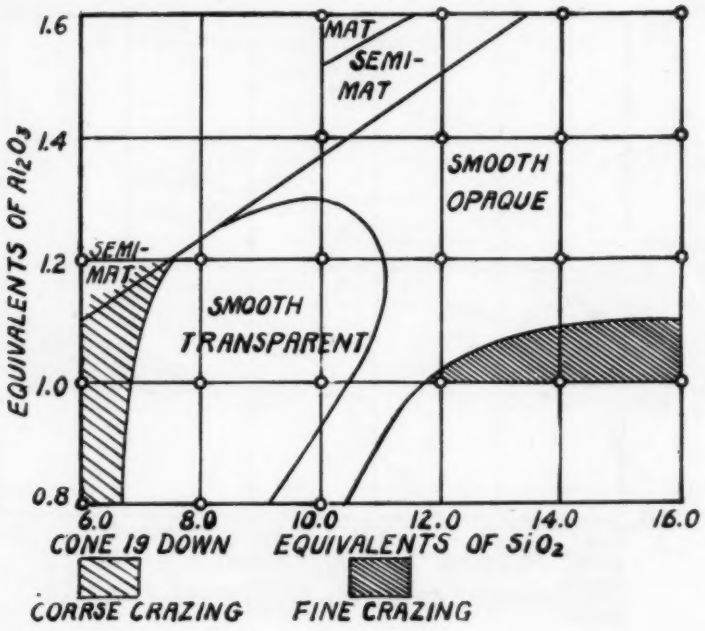
1.6
1.4
1.2
1.0
0.8
EQUIVALENTS OF Al_2O_3
MAT
SEMI-MAT
SMOOTH OPAQUE
SEMI-MAT
SMOOTH TRANSPARENT
6.0
8.0
10.0
12.0
14.0
16.0
CONE 19 DOWN
EQUIVALENTS OF SiO_2
COARSE CRAZING
FINE CRAZING

FIG. 7.

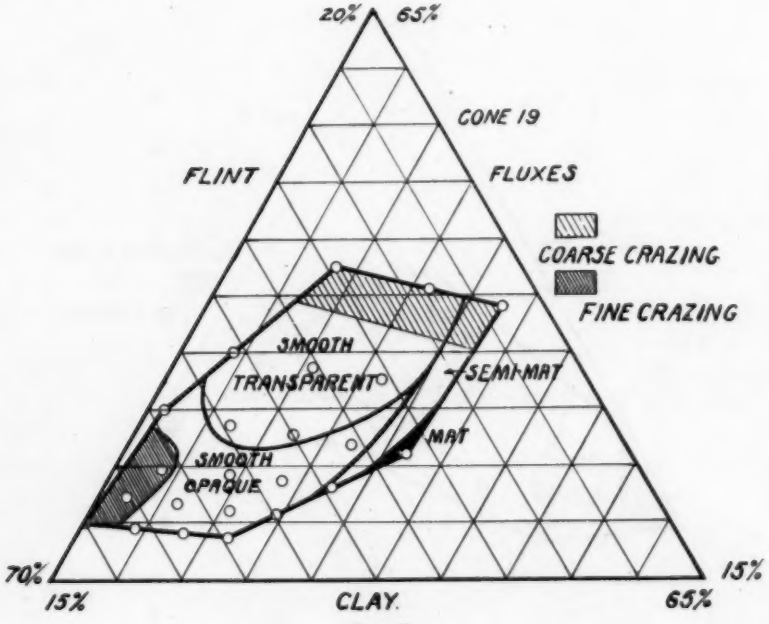
20%
65%
CONE 19
FLINT
FLUXES
COARSE CRAZING
FINE CRAZING
SMOOTH TRANSPARENT
SEMI-MAT
MAT
SMOOTH OPAQUE
70%
15%
CLAY
15%
65%

FIG. 8.

alumina:silica ratio of 1:12 for 12 equivalents of silica. The area of coarse crazing is also increased at this temperature. It includes all the glazes with 6.0 equivalents of silica. Glaze No. 23 crazed only after standing several months.

The matness of glaze No. 13 is increased, and the area of the semi-mats is increased to include No. 21; however, the appearance of the latter seems to indicate that its dull finish is due to overfiring. The areas which are termed "Transparent" and "Opaque" remain the same although it is hard to fix a dividing line. The transparent area seems gradually to be shifting toward the high flint region with each increase of temperature. The glazes with 6 and 8 equivalents of silica show a great deal of seediness, but this is greatly lessened with an increase to 10 equivalents of silica.

Results at Cone 20 Down

These glazes received a longer firing period than those fired to the lower temperatures. This will account for the relatively great change between the results at cone 19 down and cone 20 down. The fine crazed area has been totally eliminated. The coarse crazed area is also much decreased, only glaze No. 21 being so crazed. The glazes which were opaque at cones 17 to 19 are transparent at cone 20 down. The area of mat glazes is extended. The mats themselves tend more to roughness. The glazes of high flux content are overfired. They still remain transparent but tend to leave bare spots on the porcelain.

Conclusions

The approximate formula $Al_2O_3 = 0.3$ plus $^1/_{12}$ SiO_2, the alumina and silica being expressed in equivalents, seems to hold approximately true at these higher temperatures. This formula was given by Sortwell as the straight line axis passing through the locations of the best high gloss glazes. At cone 20 the locations of the best glazes are such that the line passing through them would tend to curve down into the region of lower alumina.

Fine crazing due to relatively high flint could be corrected by firing to a higher temperature. A better way would be to decrease the flint content. Coarse crazing in the glazes of high flux content seems to be caused or made worse by increased temperatures. This could be remedied by increasing both the flint and clay content, the latter to a lesser extent.

Mr. Sortwell reported that glazes containing over 55% of flint would not lie down to a smooth surface. The writer did not notice any such effect at cones 17 to 20. All the glazes marked "Smooth Opaque" even with high flint content were smooth glazes.

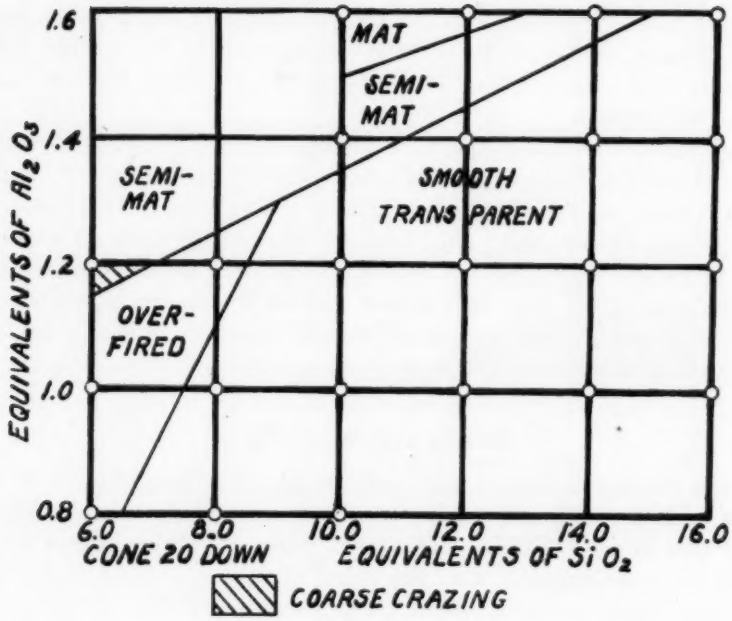
1.6
1.4
1.2
1.0
0.8
EQUIVALENTS OF Al_2O_3
MAT
SEMI-MAT
SEMI-MAT
SMOOTH TRANSPARENT
OVER-FIRED
6.0
8.0
10.0
12.0
14.0
16.0
CONE 20 DOWN
EQUIVALENTS OF SiO_2
COARSE CRAZING

FIG. 9.

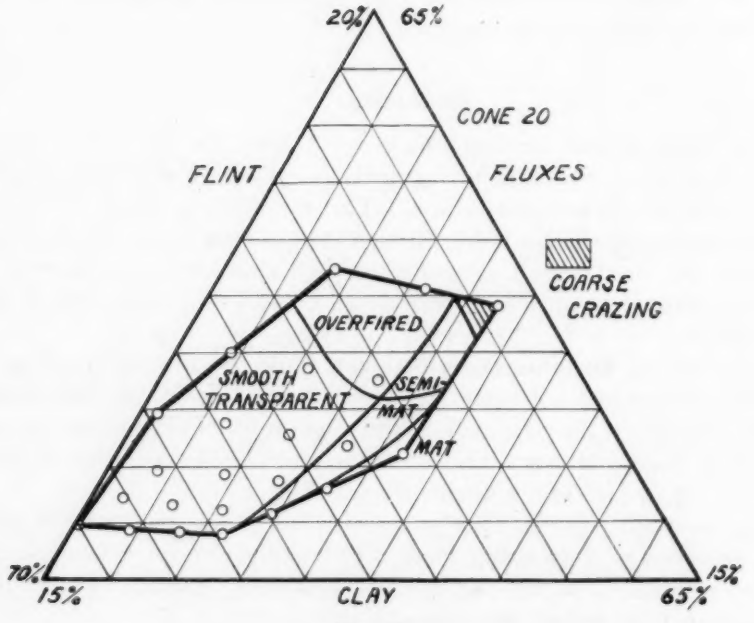
20%
65%
CONE 20
FLINT
FLUXES
COARSE CRAZING
OVERFIRED
SMOOTH TRANSPARENT
SEMI-MAT
MAT
70%
15%
CLAY
15%
65%

FIG. 10.

At any one temperature there is a wide range of compositions which will give good glazes. The best glazes for temperatures to range between 17 and 20, when fired as described, are numbers 11, 15, 16 and 19. Those glazes have ranges of composition as follows:

Clay	21.9% to 27.2%
Flint	40.8 to 51.8
Feldspar	17.2 to 23.6
Whiting	7.2 to 10.0

HIGHLAND PARK, MICH.

REDUCTION OF INDUSTRIAL WASTES[1]

By Dwight T. Farnham

Introduction

Formation of the Committee.—At the end of 1920 the Federated American Engineering Society came into being through the convening of its executive body, the American Engineering Council. On November 19th, Herbert Hoover was elected as its first President. One of his first acts was to suggest a study of wastes in industry. On November 20th a committee was appointed to make such an investigation. On January 12th, 1921, Mr. Hoover named fifteen engineers as the Committee on Elimination of Waste in Industry. The report was issued and signed by:

J. Parke Channing, *Chairman*	Herbert Hoover,
L. W. Wallace, *Vice-Chairman*	Robert Hinton,
L. P. Alford,	E. E. Hunt,
Geo. D. Babcock,	C. E. Knoeppel,
Wm. Bassett,	F. J. Miller,
F. G. Coburn,	H. V. R. Schell,
Morris L. Cooke,	Sanford E. Thompson,
Harrington Emerson,	John H. Williams,
Ira N. Hollis,	Robert B. Wolfe.

From April 1st to May 13th the reports were submitted. On July 15th the reports were approved by the Committee. It may be historically interesting to know that this Committee met in St. Louis, and the discussion as to what should go into the report and what should not go into the report started here. It is a very wonderful piece of work. The complete report is given in a volume entitled "Waste in Industry" which can be obtained from McGraw-Hill Book Company. The report is very much worth reading, because it contains data which is impossible to be given in a paper such as this. It is a great deal like some of the ceramic papers. You want to go home and take some black coffee and put some ice on your head and get down to business, to get the real meat out of them. The meat is there when once you concentrate on them.

Plan of Investigation

The investigation was based on a questionnaire. This was used to investigate all the industries, so the committee would not have a mass of data which was not correlated in any way, and so that the final result might represent the same sort of investigation in each industry. Connected with this questionnaire was a valuation sheet on which a rating was given to the different industries by the percentage system. Of course,

[1] Address given at the St. Louis Meeting, February, 1922.

an industry couldn't be one hundred per cent waste, and it was necessary to decide what should constitute waste, and how many black marks should be given in each case. Eventually, complete reports were made on men's clothing, the building industry, printing, boot and shoe manufacturers, metal trades, and textile factories. It was found that waste was attributable to *low production*, caused by faulty management of materials, plant equipment and men; *interrupted production*, caused by idle men, idle materials, idle plants and idle equipment; *restricted production* meaning production intentionally restricted by the owners and by managers, or by labor; *lost production*, caused by ill health, physical defects and industrial accidents.

The conditions in the different industries can perhaps be best gauged from the following table:

	Points assigned against		Responsibility assigned against		
Industry	Best	Average	Management	Labor	Public, etc.
Men's Clothing	26	63	75%	16	9
Building	30	53	65	21	14
Printing	30	57	63	18	9
Boots & Shoes	12	40	73	11	16
Metal	6	28	81	9	10
Textile	28	49	50	10	40
Total			Over 50%	Less than 25%	

The committee, after some debating, decided that at least fifty per cent of the waste in industry in general was attributable to management, and less than twenty-five per cent to labor.

The causes of low production caused by *faulty management* were due in these various industries to such things as:

1. Faulty Material Control.—They found, for instance, in certain shoe factories, that operatives were waiting for materials, and for orders for work about thirty-five per cent of the time. These figures that I am giving you are not caused by seasonal demands or the reverse, but delays occur when there are plenty of orders in but workmen are not able to go ahead because the tools are not ready or production orders are not ready, or conditions are unbalanced in the plant—they may have one part of the finished product but not another.

2. Faulty Design Control.—For instance, the Federal Bank check cannot be cut from any regular paper size. The variance in the size of newspapers, magazines, and so forth, costs the public over one hundred million dollars a year. The standardization of newspaper columns would save from three to five millions in composition and plates alone.

3. Faulty Production Control.—That is, lack of planning the work. In one plant the waste took up one-fifth of the workers' time in this way. Loss in clothing factories runs to thirty or thirty-five per cent. The engi-

neers figure about three-quarters of a million dollars a day could be saved by properly planning the work in the clothing industry in the United States alone.

4. Lack of Cost Control.—It is surprising how many companies have no idea what their goods cost them. In printing concerns that were looked over, fifty-six used a standardized cost system, one hundred and eighty-seven plants knew something about their costs, seven hundred and forty-one had no cost system, but had a little knowledge as to what their work was costing them, five hundred and fifty-four had no cost system and no knowledge. As a result of that, during 1919, the first two groups only made money, which is pretty good proof that a cost system is needed in a plant if it is to be run intelligently and for profit.

5. Lack of Research.—I don't need to tell anything about the necessity for that—research is what most of us here know from the ground up.

6. Faulty Labor Control.—Very few people analyze the reasons why men quit. Whenever a man quits it is necessary to break in a new man at a cost of anywhere from twenty-five to two or three hundred dollars. Various abuses occur in the usual plant which would not occur if the "quits" were analyzed and the manager knew which foremen were losing their men, and why. I have found foremen who had a turnover of one thousand per cent a year. High labor turnover can usually be reduced if certain departments can be shown how to handle their labor or some other difficulties done away with, such as those which come from inadequate rate setting.

7. Ineffective Workmanship and Faulty Sales Policy.

Study of Wastes Due to Interrupted Production

1. Intermittent Employment causes loss which has resulted in a great many idle men in certain industries. In the clothing industry, the workers are idle about thirty-one per cent of the time; shoe workers about thirty-five per cent of the time; and the building workers, thirty-seven per cent of the time.

2. Idle Material is exceedingly wasteful because of the fact that when you get a lot of money tied up in material, more material than you need, you have to pay interest on that money. That is the trouble a lot of people have been getting into the last few months. Industries have had thousands of dollars tied up in materials, and when the value of the materials dropped the business has had to take a two or three hundred thousand dollar loss. One concern recently went into the matter of the materials they had on hand, and found there was $250,000 worth of tool steel that they did not know they had. Another had about $300,000 worth of fire brick that did not appear anywhere on their books. Of course, that is

not a bad thing for the brick business, but it is pretty hard on owners at a time when they can't get money at the bank.

3. Idle Plants.—American industry is very much overbuilt. Of course you realize that in the clay business. The clothing factories are about forty-five per cent overbuilt; printing plants over fifty; and the shoe industry over fifty per cent.

Under Restricted Production Wastes

1. Closing of Plants.—The owners get together and shut down plants to shut out labor and decrease production, with the idea of getting prices up.

2. Restricted Output by Labor.—We are all familiar with the joke about the union plumber who always comes without his tools and then sends his helper back for them. Of course, systematic soldering on a large scale was due recently largely to the fact that during the war labor had things more or less in their own hands. Nobody does any more work than they have to in this world, and when there were two jobs for one man nobody did hardly any work at all, because they could go across the street and get a job which was probably better and easier.

3. Wastes Due to Ill Health of Workmen.—The economic loss from preventable disease is estimated at one billion dollars a year. The economic loss in 1919 alone from industrial accidents amounted to $853,000,000.

The remedies for the wastes we have enumerated are to a large degree disclosed by the statement of the wastes themselves. Of course, in the first place, more effective management is demanded. I am not going into that because we have plenty of literature on effective management. Since 1910 the market has been flooded with books on how to run your business, all the way from building your factory up through sales and financing. That of course is the result of the demand for more exact methods of management.

Co-operation of Labor Required

Standards of work were recommended by the Committee. It is a rather curious thing that we should pay a workman, as we do under the day work system, an exact amount of money which is measurable and then not measure the work which he does for that amount of money. If you turn the thing around the other way, and say to labor, "We will expect you to do a definite amount of work, and we will give you a piece of money," and then not specify the size of the piece of money, we would have a terrible howl from labor. Yet today labor says: "You give five dollars a day, and I will give you an indefinite amount of work" and manufacturers have been standing for it. It is a ridiculous situation.

To get away from this sort of thing piece rates were invented. The difficulty with this has been that up until the last few years, piece rates were set very largely by bargaining. A man would say, "I think I can make five boxes a day," and the boss would say, "You are crazy, you ought to make ten," and they would fight it out until finally the man would say, "Well, I will make seven," and seven it would be; when, as a matter of fact he could make fifteen if everything possible were done by the management to help him.

Scientific Standards of Labor

In the garment industry in Cleveland, about two years ago the labor unions put up half the money, while the manufacturers put up the other half of the money, to engage a firm of industrial engineers to set standards as to how many garments should be made by one person per day. I was told in England last year by a labor leader that there would undoubtedly be no objection to scientific management in the plants of England, if labor paid for the work.

This matter of co-operation between labor and capital is discussed a good deal. Their interests of course are different. Labor wants to get all it can, and the boss wants to get the work done as cheaply as possible. I feel that Secretary of Labor Wilson's analysis of the thing is the real way to work it out—labor to produce all it can, and then after the production has occurred, to sit down at a table and figure it out as scientifically as possible with the employer, as to what share should go to labor and what to capital. It is needless to say if nobody produces anything there is nothing to divide. The need of public interest in such matters is very great.

One of the things that gave the Committee a good deal of publicity was their recommendation that there be fewer style changes. I think the turnover in women's garments is three and a half a year, and in men's clothes two and a half times a year. That means men buy one suit for winter, and another suit for summer, and that there are enough dudes that buy spring and fall suits to make up the other half turnover. The women are more stylish and they buy a winter suit, a summer suit, and a spring suit, and half a fall suit. That sort of business is terribly expensive, as you who are married know. What we really ought to learn in America, is to buy on a basis of *cost per year;* I had luncheon this noon with a man who is a good deal of a student of affairs. He showed me a pair of shoes he had on, and said that he had paid $6.00 for them five years ago. That figures a little over a dollar per year. I don't know how many people figure their shoes that way, but such things should be figured. It is quite common to see in advertisements in English periodicals a letter something like this: "I am returning herewith the rainproof coat bought from you

fifteen years ago to be re-proofed." None of us do that sort of thing in this country. Try, for instance, to get your wife to buy a durable hat, and see what happens. Cost to the consumer per year is a slogan that has already been adopted by the Building Brick people.

Trade associations can do a great deal of good, and the necessity for standardization hardly needs discussion. National statistical service is necessary. There are so many manufacturers that are rushing things to the same market, "carrying coals to Newcastle," without a real knowledge of where the things are needed, and of where the market is flooded.

Principles of adjustment for labor disputes should be laid down. There is something that the Government has attempted from time to time but the condition in this country is that labor unions are so new and so much disliked by the employers that as soon as union labor and the employer get together there is immediately a fight. Judge Taft said at the University Club in St. Louis, that when he was sitting on the Labor Board during the war, they couldn't accomplish anything during the first three months because labor and capital spent all of that time telling the Board the dirty tricks the other side had been playing on them. Abroad they have been through the fight longer, and unions know what they can expect to get. However, even when they have brought in a new union like the Clerks' Union, they have about what we have in this country, because the newly made union man thinks he ought to ride in the limousine and the boss ought to walk, and until he finds out the relation of things in general he has rather a bad time of it.

Necessity for a public health policy goes without saying, and industrial rehabilitation work is very necessary. Certain industries have been employing the blind and the deaf and dumb, and it is surprising the number of people who are defective who can be used in certain sorts of work.

Necessity of Elimination of Waste

There is a certain pleasure in being wasteful and inefficient We are all familiar with the oil-county Johnny who goes down to New York and lights cigarettes with twenty dollar bills. There seems to be a sort of satisfaction in waste for certain people, but it is something we cannot afford. The statement is made in the study of waste in industry that American industry, as a whole, is much more efficient than European industry. That may be so, but at the same time we gave away during the war all the best methods in America, when they were put at the service of European industries. An Englishman who had dinner with me the other night who had been in contact with the firing line of the sales forces of the biggest industries of all Europe, said that every nation in Europe was getting ready for the race for world's trade; that they were like a lot of racers on the track waiting for the pistol to go off, but that singularly enough America didn't

seem to know there was a race on at all. The necessity for getting ready for world competition is that you have to ship goods abroad, or else there is a kind of competition that is very damaging to industry with plants working at part capacity. The best information I have been able to get on the subject is that ten per cent of our products must be shipped abroad if our plants are to be kept busy.

In competing with European labor, there are two things to be considered. One of them is the efficiency of European labor, and the other is what it is paid. I will quote some figures, to give you an idea of what the situation was in 1920. The United States was paying a first-class machinist $45.00 a week; England was paying the same man $14.70 a week; France, $8.31 a week; Italy, $5.47 a week; and Germany was paying him $4.68 a week. The men in the plants that I went through in the United States were running from four to six automatics a piece, in England one to three, in France two to three, in Italy one to two, and in Germany from three to four. Now, even if we are twice as efficient as they are over there, the pay in the United States is three to nine times as much; so we cannot afford these wastes. I had dinner with a banker in New York not long ago, and he said one of our large cable companies wanted a cable laying ship. The bid in the United States on this ship was $900,000; the French bid was about $850,000; the British bid was slightly over a million; and the German bid was $350,000.

Standardization of Materials

Now, in your own industry there are great savings that can be made by the standardization of materials. To too many of the older type of manufacturers, clay is clay. Most of you have been troubled with the farmer coming in with everything from chalk to flour, and telling you it is kaolin. So it has been with a good many of the manufacturers: they have not tested and standardized their materials as carefully as they should. Of course, some of the manufacturers have. I know one paving manufacturer, for instance, who keeps track of the particular part of the bank that the shale comes from. At one plant they had an argument as to how much sand should go into the brick, and they did nothing but argue it for two or three years, and then somebody got a bright idea and they made up brick containing no sand up to sixty or seventy per cent. Eventually they found thirty per cent sand was the best. That killed the argument.

Mechanical handling in many of the plants is very much underdone. This is especially true of the raw materials. I remember about ten years ago going to see the last word in sewer pipe factories. I was told I would see all the latest improvements. I traveled a thousand miles to see this plant and the first thing I saw was six men each in a gondola car, shoveling clay out over the fence. About twelve more colored gentlemen were

shoveling it up and wheeling it to the dry pans. That was what I had gone a thousand miles to see!

As far as I know, nobody has gotten down to brass tacks as to the correct size of kiln flues for the heavy sorts of clay ware. There have been a good many articles on the sizes that *are* used, but no one has really gone into the scientific principles of the thing. I tried it once, and made a rather poor job of it, and since that time there have been arguments as to what is a good kiln; but what really is the most effective size of the flue, has not to my knowledge been finally settled.

I hired a ceramic engineer once and his first job was to take a miner's lamp and go through all the flues. Later on after we got the top coat off these flues we couldn't see how a man that weighed a hundred pounds could have possibly gone through them. The standardization of kiln flues is absolutely necessary if you are to burn your product as quickly as possible with the least amount of coal.

The output of a plant is very often interfered with by changing equipment in the midst of production because there is not enough of the right sort of clay in the bins, because of break downs or for some other reason connected with planning the work ahead. All this means men standing around and increased costs.

Technical Control

Technical control is of course very necessary. I think people are pretty well sold on pyrometers now, but a great many have not taken the next step, that of making it worth while to the men who are handling the kiln to work to the best advantage. When kiln bottoms are standardized you can set up a burning schedule that can be adhered to from hour to hour. Once this is done the firemen can be paid on the basis of quality of product, on the basis of coal saved and on the basis of labor saved. Where you have their interest tied in, you will find wops who cannot speak English using technical instruments in ways that are almost unbelievable until you have tried it.

A good deal can be said about cost system. I remember one cost system devised for the clay business by an expert accountant who had a bright idea. He said, "Count only the spoiled stuff from the kiln; don't bother to count all the stuff, and you will save a lot of time." Inasmuch as the men who set the kilns are generally paid on a basis of how much tonnage they put in, and the men who draw the kilns are paid on the same basis, it was to the interest of both to boost the figures. Since they get blamed if they break anything, they don't report much breakage. The result was the kilns were always running from ninety-nine to a hundred and one per cent good wherever this system was put in. It is necessary to know something about the clay business and about management if you are to get anywhere with a cost system.

Organization is largely a matter of managing so everybody knows just what he is responsible for. I have found as many as five different men giving orders to the Maintenance Department in a clay plant. In such a case the Maintenance Department did the work of the fellow who had the biggest pull or who made himself most disagreeable, regardless of the necessity for the particular piece of work. The organization of a good many clay plants reminds me a good deal of a statement made by the manager of a Sheffield plant who said they drew up an organization chart showing the lines of authority, and there were so many lines all of which represented men giving orders to the same men—that they tore the whole thing up.

Administrative Control

Finally, we have what is known as administrative control, the method of determination of the policy by which to run the business. In every business there is one man who is an administrator. He is the man who makes up his mind it is a good thing to cut labor or raise wages, and that sort of thing. He, having made up his mind as to what policy should be carried out, tells the executive to go ahead. The executive's job is to deal with men—to get them to do as efficiently as possible what they should do. Administrative control deals with budgeting expenditures, financial forecasting and the like. You will find it fully explained in the May issue of *Administration* published by the Ronald Press of New York.

The annual saving due to the elimination of waste in one clay plant was as follows: on raw material handling was $8,000; on grinding and tempering $6300; and in the machine room $15,000. Machine break downs were reduced 58%. The saving in burning amounted to $14,355; the saving of coal was $39,392. Production was increased 48%. Demurrage reduced 68%. The excess men used were reduced from fifty to twenty-nine per day. Labor turnover was reduced 55%. Complete costs were furnished on the seventh of the month instead of the eighteenth to the thirtieth. Altogether the total annual saving amounted to something like $180,000 a year without counting the profit on the increased output. That sort of thing is worth considering.

I have attempted to give you a little idea of the systematic work that has been done by the Committee on Waste in Industry. My feeling is that the members of the American Ceramic Society are in a position to do more to eliminate waste in their own industry than any one else. What happens will rest very largely on how much the members of this Society interest themselves in the economic and financial aspects of the business. Gentlemen, it is up to you.

C. E. Knoepple and Co.
New York City

USE OF FORCED DRAFT FOR TERRA COTTA KILNS[1]

By John L. Carruthers

ABSTRACT

Application of forced draft system to terra cotta kilns is described. Special features are (1) type of grate used, (2) overhead air flues, and (3) use of cheap slack coal.

Advantages over natural draft system formerly used are (1) a net saving of about 20% in burning costs, (2) better control of combustion gases and kiln temperatures, and (3) uses less skilled labor for firing.

The purpose of this paper is to give a description of a forced draft system that has been successfully applied to periodic muffle kilns such as are used for firing architectural terra cotta. Incidentally, this system has been applied to round down-draft brick kilns, with very good results. No attempt is made to discuss the advantages or disadvantages of forced draft as compared with either natural or mechanically induced draft.

The terra cotta kilns on which the forced draft system has been installed are of the up-draft and down-draft muffle type, varying in size from 9 to 23 feet in diameter. No changes have been made in the design of the kilns in applying this system.

Formerly a combination inclined and horizontal grate bar furnace was used. The new grates are placed at the level of the old horizontal bars. The old fire and ash door openings have been changed to meet the requirements of the new fire door, and this is the only change made in the structure of the kiln.

The principal feature of the new system is the grate, which consists of a $^3/_{16}$″ sheet iron box and a cast iron plate, typical details being shown in Fig. 1. All joints of the box are welded. The grate plate is made in two pieces, with a ship lap at the joint. Doing this, allows a cracked or burned end of a plate to be replaced without using an entire new plate. The life of the front half of the grate plate is generally longer because part of it acts as a coking table and is not subjected to the intense heat of the rear of the furnace. The cone-shaped part of the air holes is provided in the casting, the remainder of each hole being drilled to the size needed for the particular kiln in which the plates are to be used. The weight of the plate and the style of joint between the box and plate are sufficient to hold the latter in place and to prevent appreciable air leakage at the joint. The air passing under and through the plates keeps them relatively cool and thus lengthens their life. With a few exceptions, the original plates installed eighteen months ago are still in good condition and from all appearances will last for some time.

The grate box is connected to the air flues by a 4-inch tee and nipple, the latter being welded to the box (Fig. 2). The little ash that falls through the air holes into the grate box is raked out through the tee. The plug

[1] Read before Terra Cotta Division, St. Louis Meeting, February 28, 1922.

in the tee should be taken out in case the blower is stopped while the kiln is under fire or when firing is finished. If this is not done, an explosion may take place in the grate boxes and the air flues. Such an explosion is caused by the ignition of unburned gases that are pulled into the grate box and flues by a back draft that is created with an overhead flue system when the air pressure has been eliminated. Closing the draft valves checks this back draft and removing the plugs allows a natural draft of low intensity, due to small grate openings, to be created. This procedure eliminates the danger of an explosion and also keeps the grate plates from getting too hot.

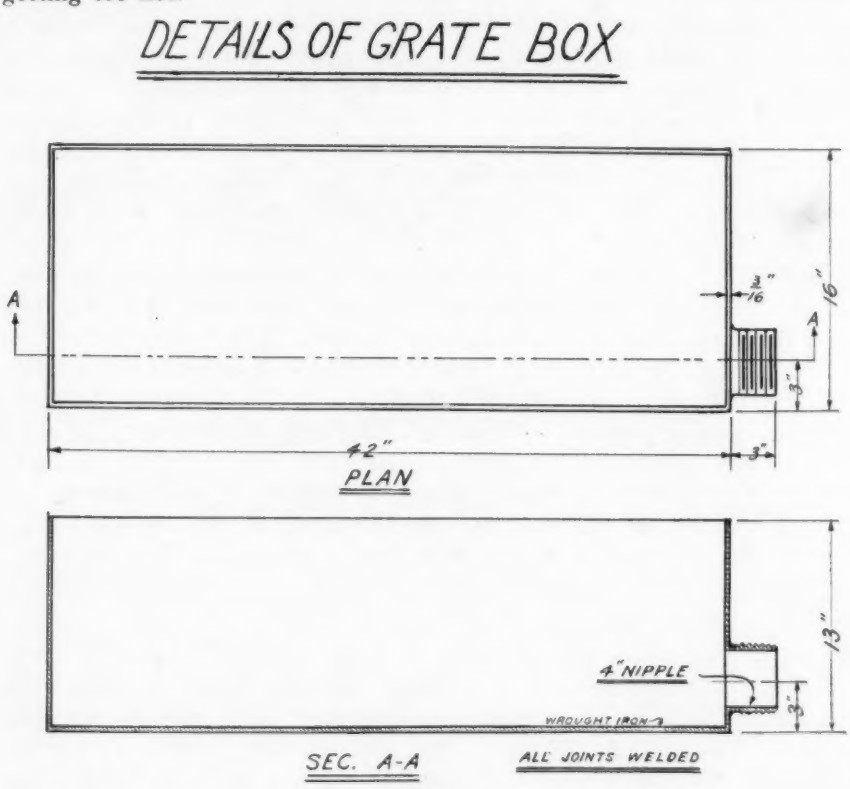

FIG. 1.

Fig. 2 also shows the type of door used and the method of hanging it on the kiln. The door is a thin cast iron box in which is placed a fire clay slab, held in place by means of set screws through the top and one side of the casting. This method of securing the slab in the frame eliminates cracks that would occur if bolts were put through the face of the slab. In case the slab does crack, the set screws can be tightened and the pieces will remain in place.

The draft is furnished by a No. 6 volume blower driven by a 5 H.P. motor. The intensity of the draft is controlled by a gate valve in the air pipe to each grate. Thickness of the fuel bed is also used to regulate burning conditions.

Fig. 3 shows a typical installation of the overhead air flue system on two of the kilns. The flues are made of 22 ga. galvanized iron. All joints

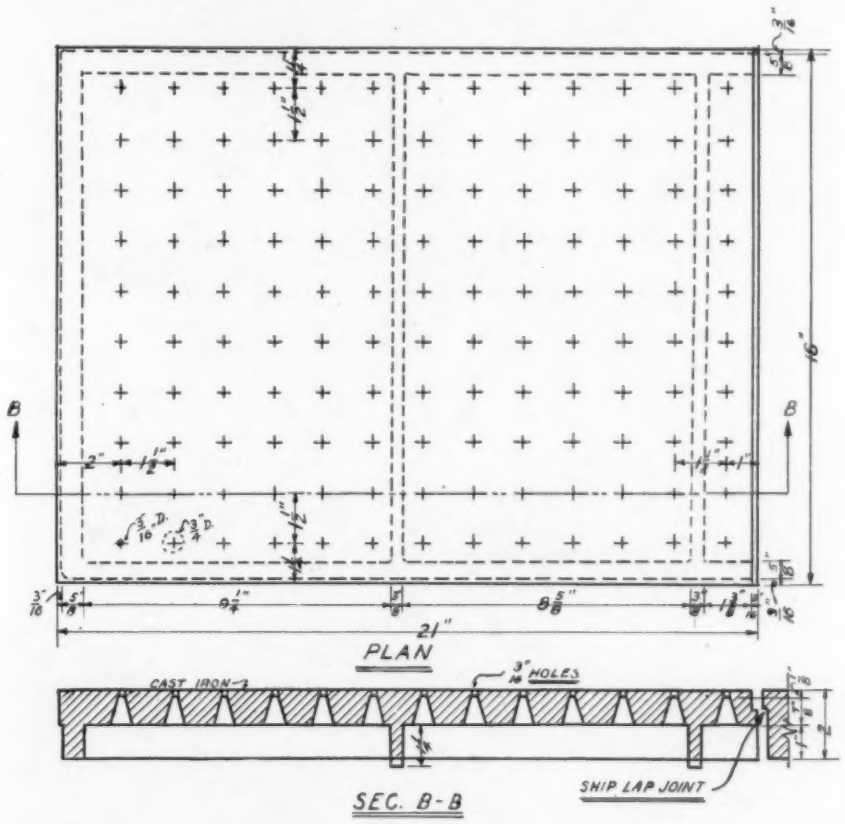

Fig. 1a.

were crimped, wrapped with cloth, and a coat of shellac applied to make them air tight. In the installation shown, the motor and blower are above the kilns. For the other kilns, a blower and motor are mounted on a platform and transferred from kiln to kiln as needed by means of a jacklift truck. Electrical connections are provided at each kiln. The use of small units requires less power than if a central blower house was maintained. Long flue systems with loss of draft due to excessive friction, and half

loaded blower equipment, that would occur at times, are eliminated. Placing the air flues above ground has eliminated the troubles ordinarily found with underground flues, such as water, and leaks that are hard to locate. The overhead system is less expensive to install than an underground one and can be more readily repaired should leaks occur.

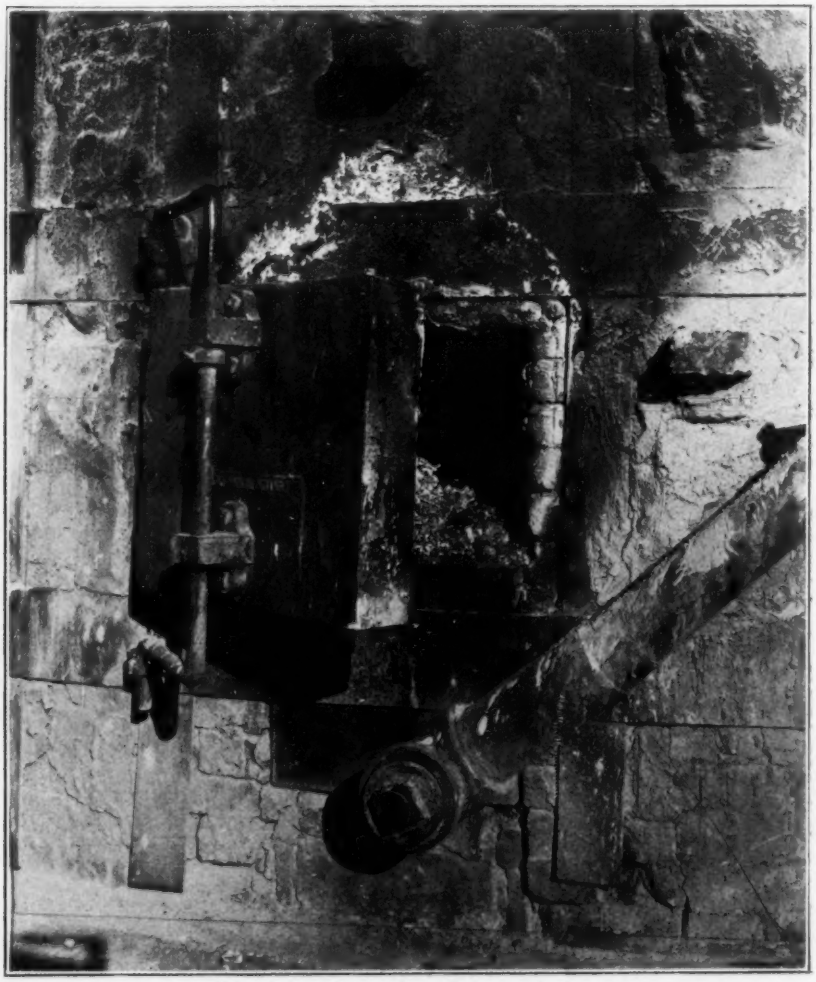

FIG. 2.

With the old type of furnace, a certain high grade of bituminous lump coal was necessary to secure good results from the firing operation. This coal had to be forked before using, the resultant slack being used as boiler coal in place of cheap lignite slack, thus increasing the cost of kiln and

boiler firing. Practically all grades of bituminous slack coal have been successfully used with the forced draft system. Slack coal has a much

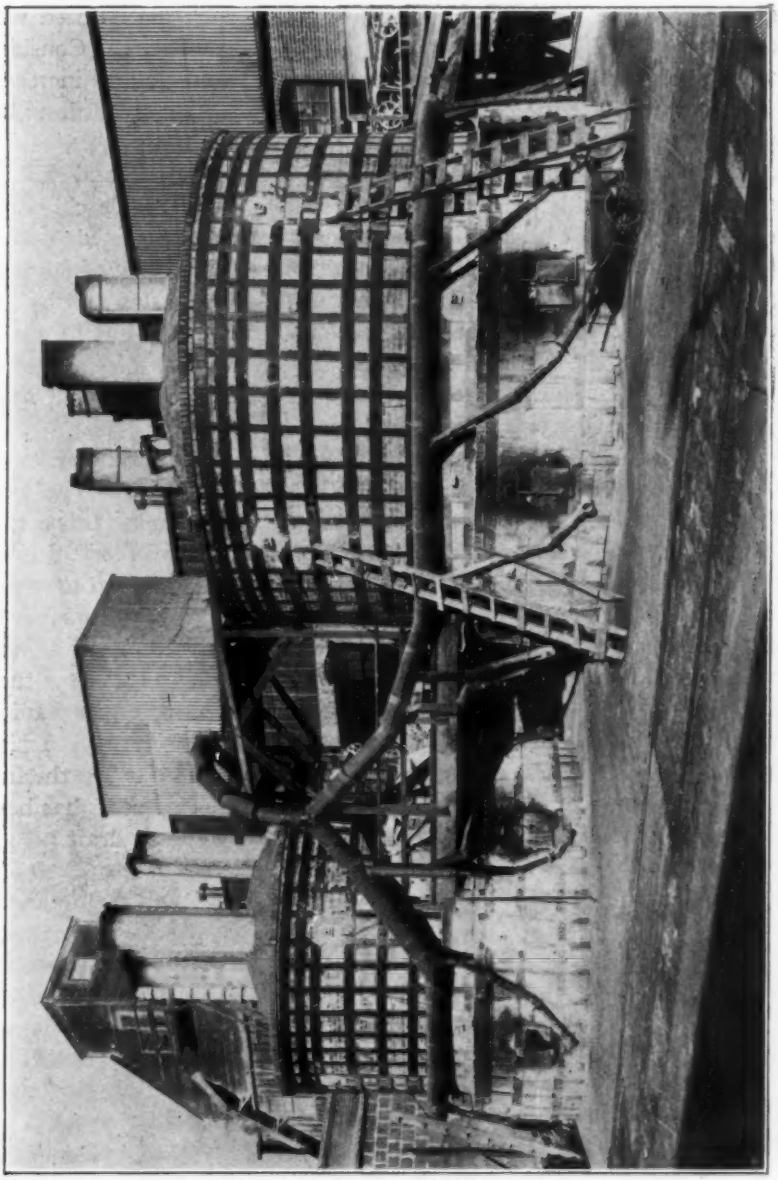

FIG. 3.

lower mine price, lower freight rate, costs less to handle and store, and makes the labor of kiln firing easier, when compared with lump coal.

For several reasons, it was considered advisable to lengthen the firing period about the time of the installation of the forced draft system, consequently the amount of coal per kiln or ton of ware has been somewhat increased. However, the firing period and coal consumption could be reduced with forced draft and still obtain a reasonable amount of good ware. Considering the initial cost of the coal, freight, handling, storing, and increased fuel consumption, the use of slack coal by means of the forced draft has cut the fuel bill almost in half, tonnage of ware being the same.

Forced draft has reduced the amount of ash, unburned fuel, and clinkers which were found with the natural draft system. Very little clinker is found along the walls because of the thin fuel bed maintained, with a consequent increase in the life of the furnace lining. Due to the high temperature in the furnace and the fine ash blown from the fuel bed by the forced draft, the walls are coated with a slag. This slag has formed a smooth coat over the furnace lining and the lower parts of the muffle. Observation to date shows that this slag coat has had little effect upon the life of the furnace or muffle linings.

The forced draft system has made it much easier to maintain even temperatures in all parts of the kiln during the firing period. The type of labor required for firing does not have to be of the same high class that was necessary when using natural draft, hence the relative cost of labor per hour has been reduced. A fairly thin fuel bed is maintained to secure the best results, which necessitates more frequent firing. The labor of firing has been made easier, though more constant, by using slack coal.

The costs of this system, excluding installation, not found when natural draft was used, are power, maintenance, and depreciation of mechanical equipment, and an increase in the total labor cost due to the lengthening of the firing period. These are more than offset by the saving in the fuel so that a net saving of about 20 per cent, in the burning costs has been secured through the replacement of natural draft by forced draft.

DENVER TERRA COTTA CO.
DENVER, COLO.

STABILITY AND DESIGN OF A KILN STACK

By T. W. Garve[1]

ABSTRACT

Introduction.—It points out the advantages and disadvantages of stack draft compared with fan draft and the necessary calculations for stability. It discusses the merits of the various cross-sections and the difference in stability of round, octagon and square stacks. (Fig. 1.)

Theoretical Consideration.—Calculations on dead weight and wind pressure are made on an average sized periodic kiln stack and the conclusion is reached that it is necessary to figure each stack section as a beam, fastened to one end, for compression and tension. (Figs. 2, 3, 4, 5.)

Practical Requirements.—A number of essential practical pointers are given for designing or building stacks, all fully illustrated in Figs. 6, 7, 8, 9.

Introduction

The advantages and disadvantages of a stack compared with a fan are as follows:

Advantages:

1. Draft always available, not depending upon any source of generated power.
2. Practically no upkeep.
3. No power consumption, wear and tear.
4. Needs hardly any attention, hence saving of labor.
5. No danger of overheating.
6. No destruction in case of fire.

Disadvantages:

1. Influenced by weather.
2. Draft limitations and limitations of control to a certain extent.
3. Exposed to the destructive elements of nature.

Fans are usually connected to continuous kilns and stacks to periodic kilns.

A proper kiln stack should answer theoretical considerations and fulfill practical requirements, yet there are many kiln stacks in existence which answer neither condition.

As regards draft conditions and temperature, size and height of stack, we refer to Lovejoy's "Burning Clay Wares."[2]

However, a stack also must be strong enough to withstand all destructive agencies, yet not so heavy that material and money are wasted.

A stack must: First, carry its own weight, and foundation and soil must safely carry the weight of the whole stack. Second, the wind pressure, acting upon the bottom of the stack column, foundation and soil,

[1] Read before the Heavy Clay Products Division, St. Louis Meeting, Feb. 28, 1922.

[2] T. A. Randall & Co., Publishers, 1920.

must safely be withstood. Third, the stack column itself in its varying cross-sections must be safe against breaking due to wind pressure.

Stacks are built square, circular, and octagon, but kiln stacks are usually built square. Kiln stacks are built single, double and quadruple. A

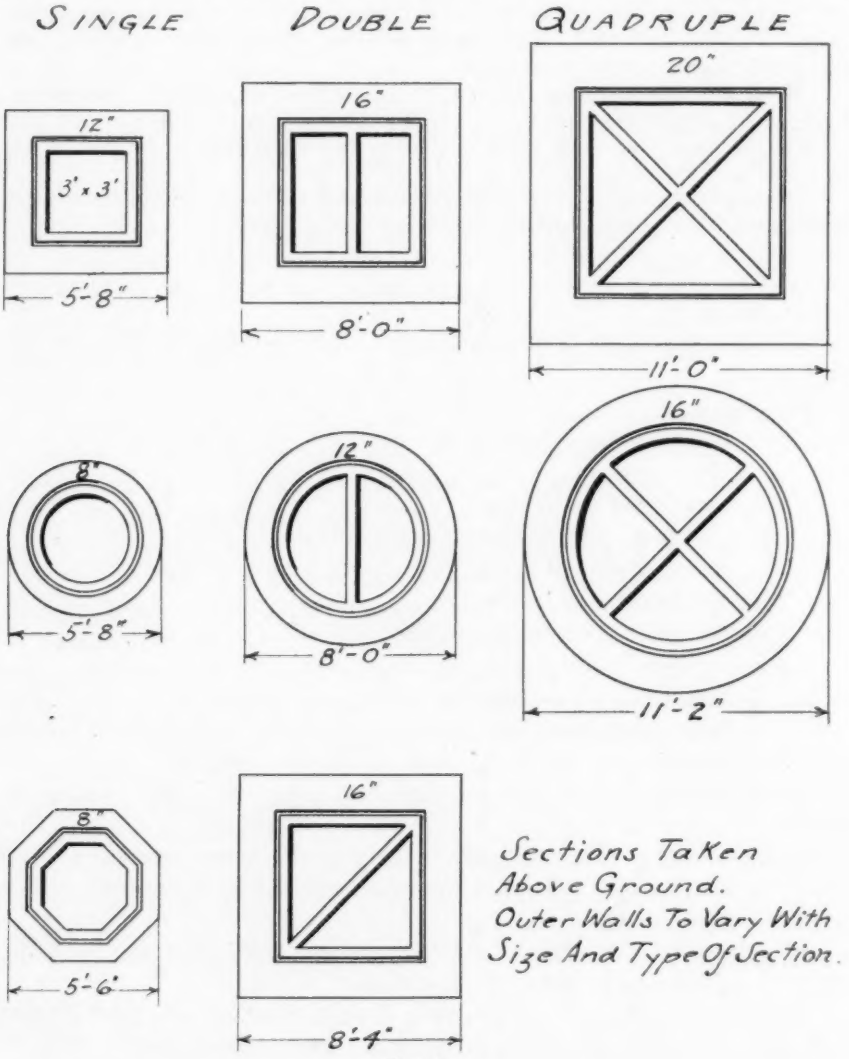

FIG. 1.

quadruple stack, of course, is cheaper than four single stacks, but it is necessary to carry the partition to the top of the stack. The cross-section of each stack flue (see Fig. 1), whether a square or a rectangle or a triangle or a circle or a semi-circle or a segment or an octagon, must correspond

to the size of the outlet required to carry out the gases, taking into consideration the friction of the gases along the sides varying with the shape of the flue and the length of its circumference.

The most economical cross-section is the circle, being shorter than the square, rectangle, triangle, or any other figure to circumscribe the same area. In addition to this, there is a greater frictional loss at the corners of a square and rectangle and especially triangle, hence these cross-sections must be made correspondingly larger in order to receive the same pull. The square cross-section comes next to the circular, and most kiln stacks are square.

Referring to the elevation of the stack column, a square stack offers a greater surface of resistance to the wind than a circular stack, hence should be made correspondingly stronger. If we call the effective wind surface of a square stack 100 per cent, the effective wind surface of an octagon stack will be 70 per cent and of a circular stack 67 per cent, which is about two thirds of a square stack. Hence if we assume in our calculations a wind pressure of 30 pounds per square foot for a square stack, we need to figure but 20 pounds for a circular stack in reference to the projected area exposed to the wind.

Theoretical Considerations

1. Safety against Crushing of Bottom Course, Concrete and Soil.—For our theoretical considerations let us assume an average stack as shown in Fig. 2.

The total weight of the brickwork (without the lining) figures 96,000 pounds. The cross-section of the botton course of brick measures 28.75 square feet, which will give a pressure of 3340 pounds per square foot, an amount very far below the allowable compression of brickwork and concrete.

The crushing strength of good brickwork with proper mortar and also of concrete is in the neighborhood of 3000 pounds per square inch, or an allowable safe load of 600 pounds per square inch (with a factor of safety of five), equal to a safe load of about 86,000 pounds per square foot.

Of course, the concrete slab should be heavy enough to distribute the weight over the soil without cracking or breaking. A two foot slab is heavy enough for any ordinary single or double kiln stack.

Upon the soil below the concrete slab we have a total weight (stack plus lining plus slab) of about 136,000 pounds or 68 tons.

Since the concrete slab measures 56 square feet, the above weight will exert a pressure of 1.2 tons per square foot which is safe for any soil. The allowable bearing values of soils from clay to rock vary from 2 tons to 20 tons per square foot; these values can be found in any engineering hand book.

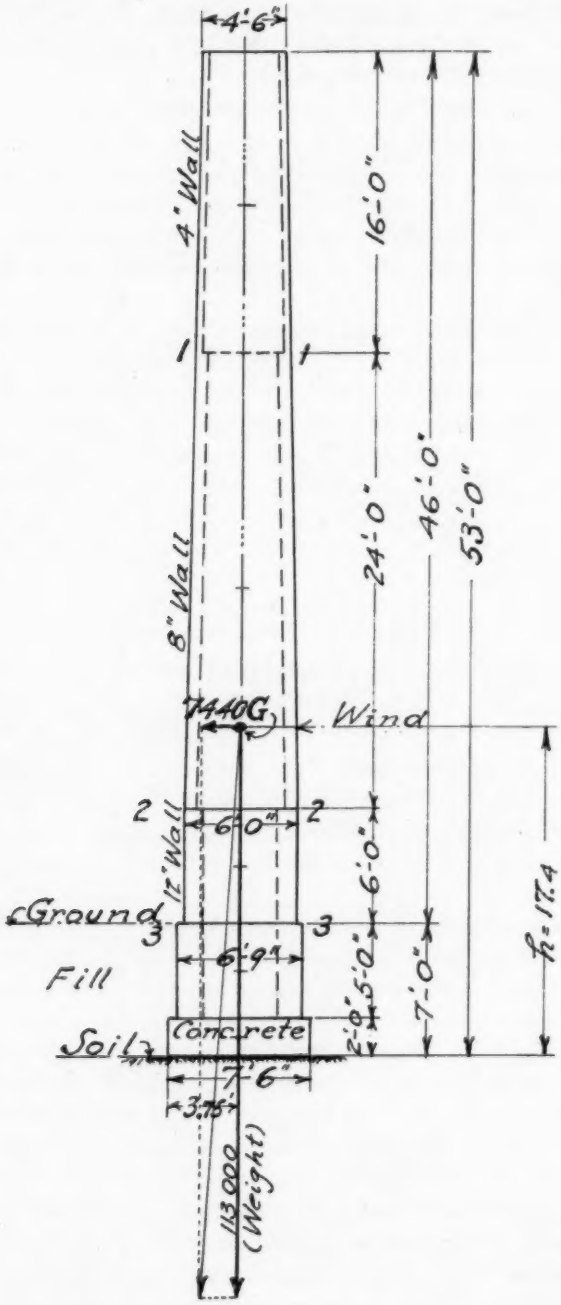
4'-6"
4" Wall
16'-0"
1
1
24'-0"
46'-0"
53'-0"
8" Wall
7440G
Wind
2
2
6'-0"
12" Wall
6'-0"
Ground
3
3
6'-9"
h=17.4
Fill
5'-0"
7'-0"
2'-0"
Concrete
Soil
7'-6"
3.75'
113,000
(Weight)

FIG. 2.

2. Safety at Base against Overturning Due to Wind Pressure (Fig. 2). —We will consider the stack as an upright column, neglecting the lining and the earth below ground since the lining should be independent and would add but very little to the stability of the stack and the earth may be removed during the construction of the stack.

The effective wind area above ground is 248 square feet. Taking a wind pressure of 30 pounds per square foot, we have a total wind pressure of 7440 pounds. This should be concentrated at the center of gravity of the total stack in reference to the bottom, hence in our case at a distance of 17.4 feet from the bottom. The wind moment or overturning moment then is 7440 times 17.4 equal to 129,456 foot pounds, and the resisting moment 113,000 times 3.75 (weight of stack without lining times distance from center to outer edge of foundation) equal to 423,750 foot pounds, exceeding the overturning moment nearly 3.3 times.

A wind pressure of 7440 pounds and a stack weight of 113,000 pounds (stack without lining) are graphically shown in Fig. 2 with a resultant but very slightly in excess of 113,000 (stack weight), hence we see that in our case the influence of the wind upon the base is negligible.

3. Safety of Stack Column against Breaking.—In order to investigate the strength and safety of the stack column, it is best to take the bottom of each section. The different sections, marked 1–1, 2–2, 3–3, in Fig. 2, have been redrawn in Fig. 3, showing the forces acting upon each section.

Section 1–1.—The effective wind area is 75 square feet and the wind pressure 2250 pounds acting in the center of gravity of this section. Hence the overturning moment is 2250 times 7.8 equal to 17,550 foot pounds.

The resisting moment is the weight times its lever arm or 12,800 pounds times 2.5 feet equal to 32,000 foot pounds.

We see that the resisting moment is 1.8 times larger than the overturning moment.

Section 2–2.—The effective wind area above this section is 210 square feet and the wind pressure 210 times 30 or 6300 pounds acting in the center of gravity of the total. Hence the overturning moment is 6300 times 16 equal to 100,800 foot pounds. The resisting moment is 58,000 times 3, equal to 174,000 foot pounds, being 1.7 times larger than the overturning moment.

Section 3–3.—The effective wind area is 246 square feet and the wind pressure 7380 pounds, resulting in an overturning moment of 7380 times 17.9 or 132,100 foot pounds.

The resisting moment is 75,000 times 3 or 225,000 foot pounds, being 1.7 times larger than the overturning moment.

We have seen that a kiln stack, so far, seems to be a very safe proposition in regard to stability. A kiln stack is very different from a power stack. In the first place it is usually a good deal lower than a power stack, and in

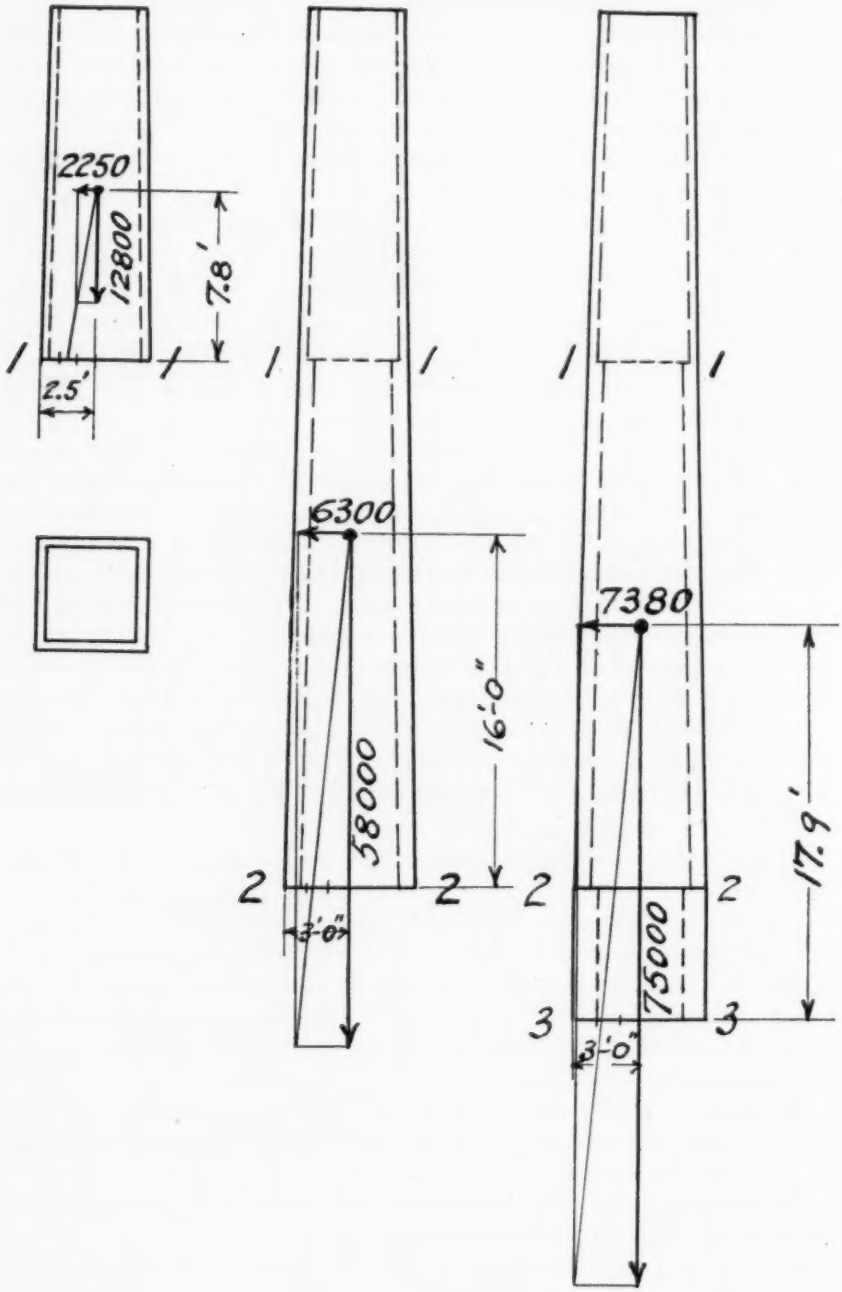

FIG. 3.

the second place the base or foundation has to be comparatively large to accommodate the underground draft flues and the additional brickwork around the flue intakes.

However, the above calculations do not take into consideration the thickness of the walls for the various sections, hence it will be necessary to figure the stack sections for compression and tension like ordinary beams, fastened at one end.

If we call

P, weight of stack or stack section
A, area of cross-section
M, bending moment
S, section modulus of cross-section

we get for the fiber stress per square foot the expression

$$f = \frac{P}{A} \pm \frac{M}{S}$$

where plus stands for half of stack column opposite the wind, and minus for half of stack column facing the wind.

All the calculations are in pounds and feet.

Hence we have:

Section 1–1 (see Fig. 4)

$P = 12{,}800$

$A = 6.3$

$M = 2250 \times 7.8 = 17{,}550$

$$S = \frac{5.1^4 - 4.44^4}{6 \times 5.1} = 9.4$$

(Section Modulus from any engineering handbook.)

or

$$f = \frac{12{,}800}{6.3} \pm \frac{17{,}550}{9.4}$$

$= 2032 \pm 1867$

$= 3899$ pounds per square foot for side opposite wind

$= 165$ pounds per square foot for side facing the wind.

Section 2–2 (see Fig. 4)

$P = 58{,}000$

$A = 10.9$

$M = 6300 \times 16 = 100{,}800$

$$S = \frac{6^4 - 4.7^4}{6 \times 6} = 22.4$$

or

$$f = \frac{58{,}000}{10.9} \pm \frac{100{,}800}{22.4}$$

$= 5322 \pm 4500$

$= 9822$ pounds per square foot for side opposite wind

$= 822$ pounds per square foot for side facing wind.

Section 3–3 (see Fig. 4).

$P = 75{,}000$

$A = 20$

$M = 7380 \times 17.9 = 132{,}102$

$S = 29$

or

$$f = \frac{75{,}000}{20} \pm \frac{132{,}102}{29}$$

$= 3750 \pm 4555$

= 8305 pounds per square foot for side opposite wind

= −805 pounds per square foot for side facing wind, being tension.

These calculations bring out the fact that practically all sections are very safe with the exception of the last section 3–3 where it faces the wind. Since the wind may blow from any direction, it is advisable to strengthen this section all around at the bottom by running the 16-inch wall a few courses higher and stepping down to a 12-inch wall, as shown in Fig. 5.

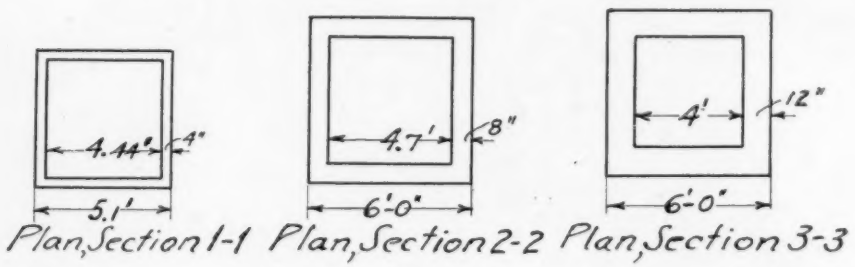

FIG. 4.

Refiguring this section now with the above correction, we get for:

Section 3–3 (see Fig. 5).

$$S = \frac{6.75^4 - 4^4}{6 \times 6} = 57$$

$$f = 3750 \pm \frac{132{,}102}{57}$$

$= 3750 \pm 2317$

= 6067 pounds per square foot for side opposite wind

= 1433 pounds per square foot for side facing wind.

While small tension values perhaps cannot always be avoided in stack design, yet a correction and hence safeguarding can easily be introduced as illustrated above.

It is necessary to make calculations referring to the thickness of the wall of each section, and it is evident that no other calculation can be considered conclusive as regards stability of stack.

Practical Requirements

For pointing out the practical requirements we refer to Figs. 6 and 7. In Fig. 6 we have a double and in Fig. 7 a single stack, both being dampered with cold air instead of a sliding gate which is of short life, mostly leaks and seldom works. The stack Fig. 7 is shown tapered while the one in Fig. 6 has perpendicular walls which sometimes can be built quicker with inexperienced bricklayers in tapered work.

A concrete slab at the bottom of the stack is a good feature to distribute the weight uniformly over the soil and to insure uniform settle. However, care must be taken to properly protect the concrete against the heat from the flue to prevent its cracking and disintegration.

It is absolutely necessary to leave an expansion joint, as shown, between the end of the main draft flue from the kiln and the stack.

The main draft flue will naturally be low on account of the kiln bottom, and it is advisable to step up at the outside of the kiln, as shown, and place the entrance to the stack just below ground. Outside of the small saving in excavation, it will enable better access of the outside air for dampering or checking the draft, and also for cooling the kiln after the burn.

It is necessary to strengthen the lower part of the stack sideways of the flue inlets, as shown on plan.

Instead of placing the cold air inlet over the flue as shown, it can also be placed in the bottom of the stack

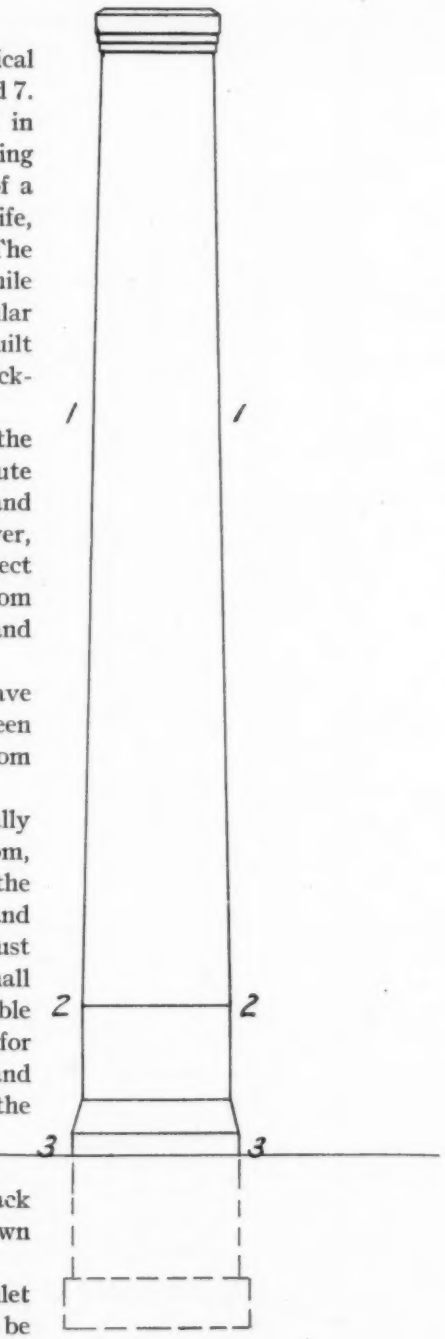

FIG. 5.

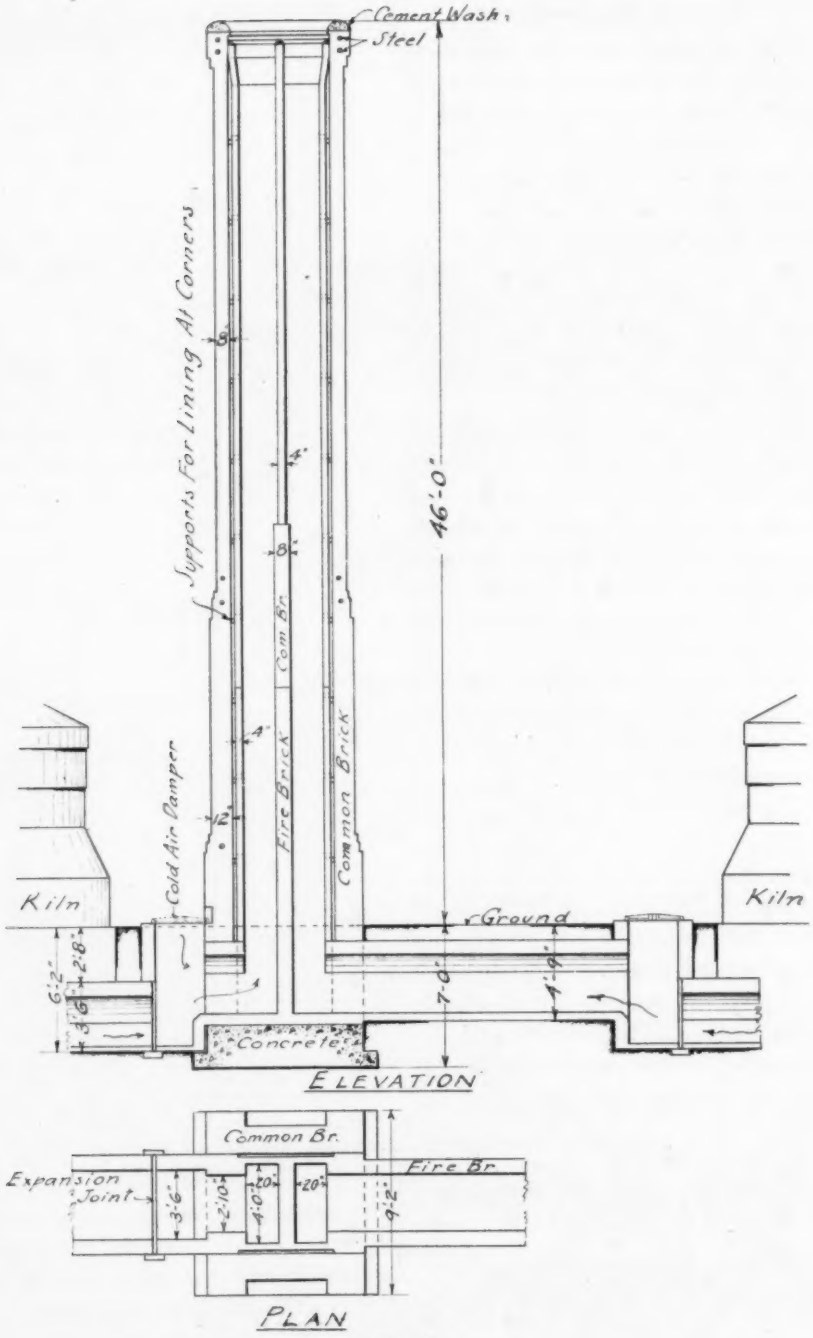
Cement Wash
Steel
Supports For Lining At Corners
46'-0"
Com Br
Fire Brick
Common Brick
Cold Air Damper
Kiln
Kiln
Ground
Concrete
ELEVATION
Common Br.
Fire Br.
Expansion Joint
PLAN

FIG. 6.

above ground, on any side of the stack except the one facing the kiln. Then we can place the stack closer to the kiln to give more room for coaling. Such an opening could also be used for an auxiliary furnace for getting draft in starting up or watersmoking. However the damper for such an opening could not be as simple and positive as the plate above the flue opening shown, and the stack would naturally be weakened here unless the opening is kept narrow or the cross-section is strengthened accordingly.

We see the fire-brick lining resting on solid foundation, independent of the outer wall and carried to the top of the stack. The lining is supported by bricks projecting out from the outer wall, two at the corner above each other, as shown in Fig. 8. In order to make sure that the expansion of the lining will not affect the outer brickwork, these projections can be staggered, in other words they go around the stack in form of a spiral and are never opposite one another. The main expansion of the lining, however, is upward and if the coping projects into the stack, there should be left enough space between the bottom of the coping and the top of the lining to allow expansion of the lining upward.

There is no reason why openings should be left in the outer brickwork which will cool the stack and diminish its pull. Only concrete stacks require such openings.

There should be no abrupt change from a heavy to a lighter wall but it should be done gradually by stepping off the brickwork.

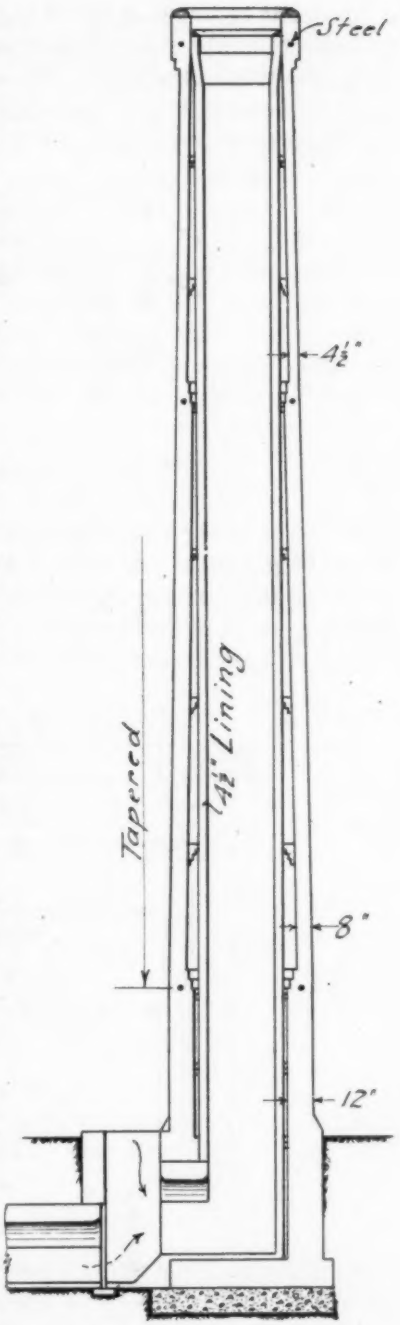

FIG. 7.

There can be found all sorts of copings, but the one illustrated in Fig. 9 we claim to be the most practical one. There is a dry joint in the lining to allow the air to escape from the air space in heating and expansion or a small hole can be left in the lining somewhere on top. A heavy concrete top and cement wash over the top will tie the brickwork and shed all

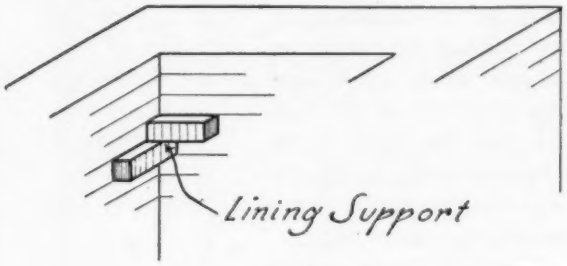

FIG. 8.

water. The lining also should have a cement wash. The cement coping should be put on as dry as possible and covered with wet rags after completion so that the surface does not dry too rapidly causing cracks. It is most important to avoid cracks in the coping because water and frost will commence their gradual destruction here, easily and unseen.

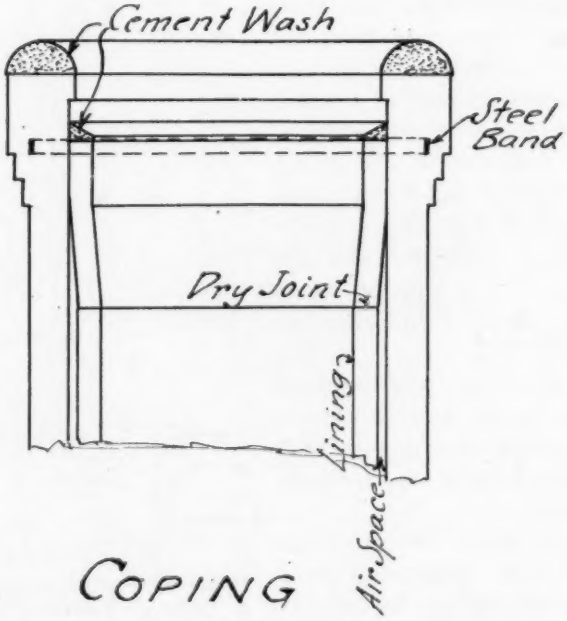

FIG. 9.

It is very good practice to embed an iron band or iron rod, in form of a closed frame, on top within the brickwork, as shown, to tie the brickwork and keep it from spreading. This can also advantageously be done in each section where a reduction in wall thickness takes place. It is a mistake, however, to use any kind of steel outside of the stack since it will rust and finally fail. The outside tieing of a stack should only be resorted to as a means for repairing and safeguarding a badly cracked stack. A properly constructed stack will not crack.

In nine cases out of ten, if the clayworker has to add more kilns and stacks to his equipment, he will build the stacks just as they have been built before, for only the reason that they stood up and hence evidently are all right. The question whether the stacks have a close margin of safety or are built with a waste of material does not enter into his mind.

Highly theoretical calculations do not have to be made, and we have pointed out a way of checking the safety of a stack with a small amount of mathematical work. The practical pointers given, we believe, are worthy of consideration. The neglect of so-called details may swing the balance from success to failure.

PAXTONVILLE, PA.

JOURNAL AMERICAN CERAMIC SOCIETY

Preparation of Abstracts

Every article in THIS JOURNAL is to be preceded by an abstract prepared by the author and submitted by him with the manuscript. The abstract is intended to serve as an aid to the reader by furnishing an index and brief summary or preliminary survey of the contents of the article; it should be suitable for reprinting in an abstract journal so as to make a reabstracting of the article unnecessary. The abstract should, therefore, **summarize all new information completely and precisely.** Furthermore, in order to enable a reader to tell at a glance what the article is about and to enable an efficient index of its subject matter to be readily prepared, the abstract should contain **a set of subtitles** which together form a **complete and precise** index of the information contained in the article. This requires at least one and often several subtitles even for a short abstract.

In the preparation of abstracts, authors should be guided by the following rules, which are illustrated by the abstracts in THIS JOURNAL for February and March, 1921.* The **new information** contained in an article should first be determined by a careful analysis; then the subtitles should be formulated; and finally the text should be written and checked.

Rules

1. **Material not new** need not be analyzed or described in detail; a valuable summary of a previous work, however, should be noted with a statement indicating its nature and scope.

2. **The subtitles should together include all the new information;** that is every measurement, observation, method, improvement, suggestion and theory which is presented by the author as new and of value in itself.

3. **Each subtitle should describe the corresponding information so precisely** that the chance of any investigator being misled into thinking the article contains the particular information he desires when it does not, or vice-versa, may be small Such a title as "A note on blue glass," for example, is evidently too indefinite a description of information regarding "Absorption spectra of glass containing various amounts of copper-cobalt and chromium-cobalt." General subtitles, such as "Purpose" and "Results" should not be employed as they do not help to describe the specific information given in the article.

4. **The text should summarize the authors' conclusions and should transcribe numerical results of general interest,** including those that might be looked for in a table of physical and chemical constants, with an indication of the accuracy of each. It should give all the information that anyone, not a specialist in the particular field involved, might care to have in his note book.

5. **The text should be divided into as many paragraphs as** there are distinct subjects concerning which information is given, but no more than necessary. All parts of subtitles may be scattered through the text but the subject of each paragraph, however short, must be indicated at the beginning.

6. **Complete sentences** should be used except in the case of subtitles. The abstract should be made as readable as the necessary brevity will permit.

7. **The ms. of all abstracts must be typewritten and double or triple spaced.**

* The rules were prepared by the Research Information Service of the National Research Council. The Society is indebted to Dr. G. S. Fulcher of the Corning Glass Works (formerly with the National Research Council) for the rules and the illustrative abstracts.

CERAMIC ABSTRACTS

Compiled by the

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General and Miscellaneous

1. Experiments with heat interchangers. F. R. BICHOWSKY. *J. Ind. Eng. Chem.*, **14,** 62–64(1922).—In liquid air machines and other refrigerators the loss of efficiency due to poor thermal insulation ordinarily is small compared with that due to poor interchange. The efficiency of heat interchange was studied by means of an apparatus consisting of a gas-conducting tube, 0.124 in. in internal diam., through which was stretched centrally a wire of No. 40 constantan. Leads of No. 40 copper wire were connected with the ends and the middle of the constantan wire, the whole forming a differential thermoelement giving the temperature of the gas at these points. The tube was immersed in a bath of liquid air. The temperature drop per unit length of tube was independent of the pressure, inversely proportional to the rate of flow of gas through the tube, and proportional to the temperature head from bath to incoming gas. A formula is given by which it is possible to calculate the length of tubing necessary for an ideal interchanger of given thermal efficiency. The results accord with practice in interchangers of the best design. Liquefiers of copper tube, flattened, and twisted to enable it to stand high pressure without bulging, may give an efficiency of 70% of theory.

H. M. (*Jour. Chem. Ind.*)

2. Burning of pulverized fuel in paper mill power plants. LOREN L. HEBBERD. *Tech. Assoc. Papers,* **4,** No. 1, 13–21(1921).—A general exposition of the advantages of using pulverized fuel in paper mill power plants, both in new mills and in old mills at present operating with stokers, with estimates of costs and savings. Discussion.

A. P.-C. (*C. A.*)

3. Volumetric and gravimetric methods for the determination of zinc in practice. STEFAN URBASCH. *Chem.-Ztg.*, **46,** 6–7, 29–30, 53–5(1922).—In these 3 installments, the treatment of Zn ores, the effect of impurities, and details concerning titration with $K_4Fe(CN)_6$ are discussed and the results of certain test analyses are given. To dissolve the ore, treatment with about 20 cc. of 12 *N* HCl, 1 cc. of concd. HNO_3 and enough HF to react with SiO_2 is recommended, after which the soln. is evapd. to fumes with 7 cc. H_2SO_4. To remove metals of the Cu group, treatment with H_2S appears to be indispensable. Fe, Mn and Al are best removed by treatment with Br and the presence of a suitable concn. of NH_4OH and NH_4Cl. The removal of Al is shown to be necessary and the effect of NH_4 salt is noticeable, but best compensated by standardizing with the same concn. as in the analysis. Instead of using an outside indicator, it is better to add about 0.2 mg. of Fe to the soln. in the form of $FeCl_3$ and then, in the hot soln., the end-point is reached when the color changes from pale blue to white or pale yellow. It is well to add a slight excess of ferrocyanide and titrate back with standard Zn soln. The ferrocyanide soln. will keep indefinitely if kept in contact with H_2. W. T. H. (*C. A.*)

4. A new method for the detection and estimation of cobalt. S. A. BRALEY AND F. B. HOBART. *J. Am. Chem. Soc.*, **43**, 482–4(1921).—A brown color is always obtained when a soln. contg. Co is treated with dimethyl glyoxime and the color does not disappear, as does that of most oximes, upon the addn. of mineral acids. This color reaction may be used as a test for Co in the absence of interfering substances such as Cu and Fe and as a basis for the colorimetric detn. of Co. W. T. H. (*C. A.*)

5. Activity coefficients and colligative properties of electrolytes. H. S. HARNED. *J. Am. Chem. Soc.*, **44**, 252–67(1922).—On the basis of an empirical equation $\log F_a = \alpha c - \beta c^m$ which relates the activity coeff. (F_a) of an electrolyte with the mol. concn. (c) at a given temp. (α, β and m being consts.) and Duhem's equation, $N_1 d\alpha F_1 = -N_2 d\alpha F_2$, where N_1, N_2, F_1 and F_2 are mol. fractions and free energies of the electrolyte and water, equations are derived for calcg. vapor pressures of solns. In all the 13 electrolytes studied the empirical equation holds up to $3M$, above which the equation fails for H_2SO_4 and HCl. A special study of the activity coeffs. of KCl, NaCl and HCl was made and the parameters (α, β and m) for the 13 electrolytes were tabulated, from which the vapor pressures and osmotic pressures can be calcd. The equation, admittedly empirical, should prove useful in testing existing data and in organizing colligative data of concd. solns. JAMES M. BELL (*C. A.*)

6. Patent legislation and the chemical industry. ANDRÉ TAILLEFER. *Chimie & industrie*, **6**, 845–7(1921).—Discussion of process patents and product patents. A. P.-C. (*C. A.*)

7. The phenomena of layer formation in clay suspensions and their application to soil analysis. E. UNGERER. *Kolloidchem. Beihefte*, **14**, 63–96(1921).—The literature is reviewed. Expts. were conducted with centrifuged suspensions of ultramarine blue and ultramarine red, as well as by settling under the influence of gravity. Samples were removed from each distinct layer of the suspension, and the no. of particles counted. The size of the particles was also calcd. from the Stokes equation (size of particles expressed as function of velocity of settling, viscosity of the medium, d. of particles, d. of medium). Observed and calcd. values agree well. Emulsions (gum arabic, oil and H_2O) exhibit the same phenomena. To det. the conditions for the formation of layers, the size and d. of the individual particles must be considered; each sep. layer indicates particles of definite size. Different strata indicate definite differences in wt. and size of the particles. Each layer reaches to the bottom of the contg. vessel. Const. temp. conditions influence largely the formation of definite strata of turbidity. The layers are formed equally well in suspensions contg. electrolytes and in those which are electrolyte-free, excepting electrolytes with marked coagulating power. The particles of each stratum sink (or rise) with equal velocity. From the velocity of falling (or rising) with the help of the *Stokes equation* one can establish the characteristic size of each group in contact with solid surfaces, and are not due to higher free energy content of atoms in nascent state because when mols. are dissociated by heat the resulting atoms show no properties, save those arising from increase in number, not already shown by the undissociated mols. By causing H to bubble in a soln. through a filter paper extn. thimble, Z. found a soln. of $HgCl_2$ was appreciably reduced. Similarly O oxidized NH_3 to HNO_2 and N and H united sufficiently to give a reaction with Nessler's reagent. J. C. (*C. A.*)

8. Molecular structure of amorphous solids. C. V. RAMAN. *Nature*, **109**, 138–9 (1922).—The magnitude of the scattering of a beam of light by glass lends support to the view that the arrangement of the mols. is irregular rather than that they are packed together at more or less uniform distances apart as in crystals. W. H. R. (*C. A.*)

9. Research laboratories in industrial establishments of the United States, including consulting research laboratories. A. D. FLINN AND RUTH COBB. *Bull. Natl. Research Council*, **3**, Pt. 1, 1–135(1921). E. J. C. (*C. A.*)

10. Fuller's earth deposit at Olmstead, Ill. C. W. PARMELEE. *Chem. Met. Eng.*, **26,** 177(1922).—Fuller's earth is being mined at Olmstead, Ill. for use in the bleaching of oils. The total amt. available is estd. at 4 million tons, and its advantageous location will probably make it comp. important. EDW. F. HOLDEN (*C. A.*)

11. Centrifugal decantation. R. BERLINE. *Chimie & industrie*, **6,** 737–45(1921).—An outline of the theory of centrifugal decantation with a brief description of various types of comp. app. A. P.-C. (*C. A.*)

12. Industrial research and patents. C. L. JENKS. *Chem. Met. Eng.*, **26,** 394–7 (1922). E. H. (*C. A.*)

13. Corrosion of a producer-gas cooling system. LLOYD E. JACKSON. *Chem. Met. Eng.*, **26,** 60–4(1922).—The system consisted of dust catchers, collecting mains and condensers, into all of which cooling water was sprayed. The water was caught in a decanter, pumped 550 ft. to spray ponds, passed through a coke filter and pumped back through the system. Make-up water was added from the Providence city mains. After 6 mos. operation leaks appeared, especially in the 550 ft. main to the spray pond. The hot water in this main was acid and contained suspended coke dust. Tests showed that while the life of this 6 in. main under corrosion alone would be 10 yrs., erosion from the coke dust reduced it to 9 mos. Remedies suggested were: (1) To use fresh cooling water from wells and waste it into the bay after it went through the system once. (2) To use brackish water from the bay in the same way. (3) To recirculate fresh cooling water after filtering out the coke dust and treating with lime for acidity and with iron turnings for dissolved O. The results of numerous expts. are given and the suggested remedies discussed, but there is given no final conclusion as to which remedy was or should be adopted. J. J. MORGAN (*C. A.*)

14. The Santa Barbara 500-ton mill for concentrating lead carbonate ores. F. M. HEIDELBERG. *Eng. Mining J.*, **112,** 1050–7(1921).—A description of the new mill of the American Smelters Securities Co. at Santa Barbara, Chihuahua, Mexico, with flow sheets and detailed data on equipment. Au and Ag are present in small but paying amt. A. BUTTS (*C. A.*)

15. Comparison between laboratory fuel tests and practical working results of the producer-gas process. N. E. RAMBUSH. *J. Soc. Chem. Ind.*, **40,** 293–300T(1921); cf. *C. A.*, **15,** 2981.—R. describes a method and app. for detg. in the lab. the practical tar yield of fuels and gives the results obtained on the same fuel in the lab. and on large-scale gasification. The ordinary fuel analysis, especially in regard to the volatile content detn., is generally insufficient to predict the gasification products. Such a process as the one described should predict with reasonable accuracy the thermal efficiency, the quality of the gas, the possible yield of by-products such as tar and NH_3 from particular coals, as well as the type of plant to be employed. The app. consists primarily of a simple horizontal distn. retort with a condensation and absorption train. Two kg. of fuel are distd. gradually up to 800° from 4–6 hr. and the amt. and compn. of the distillate detd. by the usual methods. Data from a no. of expts. are given and compared with results obtained on actual producer plants and the relationship is shown to be very close. It is concluded that a tar recovery, in practice, of 80% could be obtained, and also it should be possible to det. the heating value of the gas from a particular coal by observing the relation between the coke gasification efficiency and the gas heating value. Fuels of fine grading require large gasification areas, and those of high-caking properties to be stirred mechanically, those of high ash content mech. grates, while those of high tar yield should be gasified at low temps. to give the highest yield of light tar oils, and those with high moisture content require a deep fuel bed in order to properly utilize the sensible heat of the gases. Fuels with high volatile content show thermal decompn. upon distn., such heat would, however, not be lost for the purpose of producer-gas production. J. L. WILEY (*C. A.*)

16. Twenty-eighth annual report of the Committee on Atomic Weights. Determinations published during 1921. G. P. BAXTER. *J. Am. Chem. Soc.*, **44,** 427–37(1922); cf. *C. A.*, **15,** 1095.—Detns. on B, O, F, Cl, Ni, Zn, Ge, Cd, Sb, La and Bi are reviewed. E. J. C. (*C. A.*)

17. Investment in chemical education in the United States, 1920-1921. C. J. WEST AND CALLIE HULL. *J. Ind. Eng. Chem.*, **14,** 237(1922). E. J. C. (*C. A.*)

18. Auxiliary electrochemical developments for hydroelectric plants. H. K. BENSON. *Chem. Met. Eng.*, **25,** 1004(1921).—Of the chem. processes utilizing elec. power only a few are capable of operating intermittently on the off-peak power of a municipal hydroelec. plant. As a means for increasing the load factor of the new Skagit power plant at Seattle, Wash., the following process are preferred in the order given: the elec. are fixation of N; the electrochem. production of P_2O_5; the production of electrolytic H and O (in the event of the nearby location of a hydrogenation industry this process would rank second if not first); the production of NaOH or org. chemicals.

LOUIS JORDAN (*C. A.*)

PATENTS

19. Ceramic vessel. FREDERICK S. LOWRY. U. S. 1,400,489, Dec. 13, 1921. A ceramic vessel consisting of a body structure composed of compositely united inner and outer layers; the outer layer is composed of a mixt. of fire-clay, sand, manganese, and water suitably molded into receptacle form; the interior layer is composed of fire-clay, and water, the inner layer serving to impart a smooth finish to the interior of the vessel so that a glaze may be applied thereto. C. M. SAEGER, JR.

20. Condenser for shale-oil, etc. J. A. BISHOP. U. S. 1,395,898, Nov. 1. Vapor to be condensed is passed through staggered vertical pipes cooled by air passed horizontally around them. The air is cooled by contact with H_2O-cooled brick walls. (*C. A.*)

21. Plastic composition and process for making the same. REIMAN G. ERWIN. U. S. 1,409,088, March 7, 1922. A compn. of matter comprising mineral dust of colloidal nature suspended in bitumen and combined with sodium chloride, sodium sulphate and sulfur derivatives in the following propns.: of dust and the above mentioned chemicals 40 to 60%, of bitumen 40 to 60% and an aggregate comprising mineral particles; 40 to 60% of such aggregate are suspended in from 60 to 40% of the bituminous compn. C. M. SAEGER, JR.

22. Plastic-block mold. ERNEST JOHN BENSON. U. S. 1,408,685, March 7, 1922. A block mold comprising a rear end wall; side walls hingedly connected to the rear end wall for outward swinging movement; groove-forming members secured to the confronting sides of the side walls and each comprising a flexible tubular member; a rod for securing the member in position upon the wall; a front end wall detachably secured to and spanning the side walls; duct forming members secured to the inner sides of the front end wall, each of these comprising a core and a jacket embracing the core.

C. M. SAEGER, JR.

Apparatus and Instruments

23. Apparatus for electrically heating liquid and solid chemicals. ANON. *Engineering*, **92,** 852(1921).—In a resistance type of heater, an a. c. is passed through the liquid to be heated, which flows down a cascade or step-ladder effect. The heat is controlled by alteration of the cross-section or length of the stream, or of the applied voltage; single- or 3-phase current may be used. Solid chemicals may be heated in an induction type of app., in which coils carrying an a. c. are arranged in such a relation to the surface with which the chemical is in contact that the induced current and hysteresis effect in it generate the necessary heat; temp. control is effected by regulation of the current.

This latter app. has been applied to rotary and drum driers, shelf driers, hot grinding pans, pumps, and delivery pipes. T. S. CARSWELL (*C. A.*)

24. Recessed plate and plate and frame filter presses: their construction and use. E. A. ALLIOTT. *J. Soc. Chem. Ind.*, **39**, 261–85T(1920).—This paper gives a detailed study of the construction and meaning of the many variations in type of filter presses, their use and data incident to operation including large scale operation figures. A given material varies greatly in filtering qualities because of slight variations in mfg. processes. The problem is hence very difficult and diverse. In the recessed plate press, the rims of the plate are raised so that a hollow chamber is formed when 2 plates are brought together. The feed passage is through the body of the plate and cloth is laid over each side. This type is the least expensive and requires less labor. It is suitable for cakes from 1 to 2 ins., depending on the size of the press. The second type of press is especially suited to the formation of very thick filter cakes or for filtering materials that tend to rot the cloth, for the plates are flat, the chambers being formed by placing hollow frames between the plates and the cloth therefore lies flat on the plates. In this press, filter paper can also be used. This type is not suitable for thin cakes or lumpy material because the feed openings which are through the rims of the frames are often very small. The plates of filters may be made of wood, iron, vulcanite (for strong HCl), etc. The best woods for strong acids are coniferous. Oak is best for CH_3COOH. Impregnation of the wood is of doubtful value as far as increasing its resistance to acids. Cocks are preferable to valves which, if used, should be of a kind easily cleaned. Small batches may be filtered in a large press by making use of a dead plate. The simplest closing gear (center screw pattern) is the most satisfactory. A. gives special facilities for the care of the cloth and advises the use of a pulp cake for filtering liquors contg. small quantities of fine ppt. For recessed plate type, double cloths are used and various methods of application of the cloth to the press are detailed. The design of the filter press depends upon a number of factors, chief among which are: quantity to be filtered, chem. properties, suitable cake thickness, working pressures, cloth, time required or rate, size of particle, etc. Tests on a small scale are run to get basic data. All of these factors are taken up mathematically, formulas being derived and curves being drawn covering not only the design and proper working and operation, but also the feed and washing and economical aspects including labor. The paper is exceptionally clear and detailed and is profusely illustrated with drawings, photographs, and photomicrographs. P. D. V. MANNING (*C. A.*)

25. Electric heat for thermal processes. E. F. COLLINS. *J. Ind. Eng. Chem.*, **14**, 101–4(1922).—An oven for baking automobile engine cores gave an efficiency of 11.6 lbs. of cores per kw.-hr. Japanning ovens are in use requiring over 3000 kw. to heat and turning out one automobile per min. Electrically heated glass annealing ovens show 20% lower cost than gas-heated lehrs. The muffled arc type of elec. furnace will melt 1500 lbs. of brass per hr., with a metal loss of less than 1.5% and a power consumption of not more than 270 kw.-hrs. per ton. Cu is melted at the rate of 1300 lbs. per hr. at 350 kw.-hrs. per ton. Other applications are in baking vitreous enamels, cartridge unit-heaters and glue melting pots. Also in *Beama*, **10**, Pt. 2, 3–25(1921). A. C. LANGMUIR (*C. A.*)

26. New Brown cold junction compensated pyrometer. ANON. *Chem. Met. Eng.*, **25**, 757–8(1921).—The cold junction of the thermocouple is brought to the pyrometer box; a Briguet spiral (compound strip of 2 metals of different coeffs. of expansion) is mounted on the moving member so that as the reading due to the difference between the temp. of the two junctions decreases with increasing temp. of the cold junction, the zero reading of the pointer is advanced. In this way the true temp. reading is obtained irrespective of the temp. of the cold junction. A smaller pointer actuated

directly by the Briguet spiral establishes the zero point of the instrument to allow resetting when necessitated by jars or by long service. DONALD W. MACARDLE (*C. A.*)

27. Setting a recording pyrometer for cold-junction temperature. KIRTLAND MARSH. New Kensington, Pa. *Chem. Met. Eng.*, **24,** 1152(1921).—In the case where the galvanometer scale does not come down to the cold-junction temp., the pointer is set for any convenient low temp., A, then, by an adjustable small e. m. f., is deflected by an amt. $A - C$, where C is the cold-junction temp., and then set to A while the small e. m. f. continues to be applied. On open circuit the pointer, though off scale, now reads C, which is the necessary adjustment. W. P. WHITE (*C. A.*)

28. Pyrometry. Color temperature and brightness of various illuminants. E. P. HYDE AND W. E. FORSYTHE. *Trans. I. E. S.*, **16,** No. 8, 419–30(1921).—Color temps. for many light sources are given including:

Gas flame—batswing	2160°C
Gas flame candle shape	1875
Sperm candle	1930
Paraffin candle	1925
Standard Pentane Lamp 10 C. P.	1920
Flat wick kerosene lamp	2055
Round wick kerosene lamp	1920
4. w. p. c. carbon	2080
3.1 w. p. c. treated carbon	2165
2. w. p. c. osmium	2185
2. w. p. c. tantalum	2260
Acetylene as a whole	2380
One spot acetylene	2465
Mees burner	2360
1.25 w. p. c. tungsten	2400
2.3 w. p. c. Nernst	2400
Sun outside atmosphere	6500
Sun at earth's surface	5600

WM. M. CLARK

PATENTS

29. Drying apparatus. M. MOMOTANI. Jap. 37,903, Jan. 26, 1921. A conical vessel, in which spiral stairs are fixed, is provided with an elec. heater and drier for air. Materials are charged from the top; dried air is introduced from the bottom. (*C. A.*)

30. Viscosimeter. H. N. MOODY. U. S. 1,405,538, Feb. 7. (*C. A.*)

31. Gas-analysis apparatus. E. H. DELANY AND S. H. PAYNE. U. S. 1,395,560, Nov. 1. Gas to be tested, *e. g.*, flue gases for CO_2 detn., are passed into a liquid absorbent such as NaOH soln. in a tower provided at its top with gages for registering differences in pressure caused by the absorption. (*C. A.*)

32. Thermocouple. M. A. HUNTER. U. S. 1,393,375, Oct. 11. A thermocouple is formed of 2 elements producing, when heated, or cooled, a substantially linear e. m. f.-temp. curve; one of the elements is an alloy of Cu 50–75, Ni 50–25 and Cr 5–30 parts which is refractory and highly resistant to oxidation and the other element is an alloy of Ni 100 with Cr 10 parts. (*C. A.*)

Chemistry, Physics and Geology

33. Brick testing by the Brinnel Ball Method of Le Chatelier and Bogitch. *Rev. Mat. Constr. Trav. Pub.*, **147,** 240(1921).—(Read before the French and Belgian members of the I. A. T. M. by Mr. Guillery.) A ball 17.5 mm. in diam. is sunk onto a test brick

covered with a leaf of tinsel $^1/_{10}$ mm. thick, that has been blackened with hydrogen sulphide. Oblique jamming is prevented by ball bearings. A constant pressure of 500 kgs. for 1 min. leaves an imprint on the foil, the diam. of the impression being an indication of the brick's resistance. The method is rapid, sensitive and leaves the brick practically unaffected. LOUIS NAVIAS

34. Temperature coefficients of the electrical conductance of pure metals. L. HOLBORN. *Seit. für Physik.*, **8**, No. 1, 58–61(1921).—The observed values for heated metals between 0° and 100° are given below.

Ni	0.675	Rh	0.443	Ir	0.411
Co	0.658	Mo	0.435	Ag	0.410
Fe	0.657	Cu	0.433	Au	0.400
W	0.465	Cd	0.424	Pt	0.392
Bi	0.446	Pb	0.422	Pd	0.377
Al	0.445	Zn	0.415	Ta	0.347

WM. M. CLARK

35. Particle-size analysis of granular and powdered materials. FERET. *Rev. Mat. Constr. Trav. Pub.*, **147**, 237–39(1921).—(Read before the French and Belgian members of the International Association for Testing Materials.) F. describes and criticizes generally three methods of sepg. a material into divisions according to sizes of particles, namely for wet sepns., by sedimentation and by levigation, and for dry sepns. by currents of gas. F. has proposed a classification of particles according to sizes, which he submits to the Association and to the permanent Commission of Standardization with the hope that it will become international. The group names are the French names which F. has coined from the words given in parenthesis after them. The numbers refer to the max. and minimum dimensions for any group in mms.:—Primary Groups, "Nucles" (**nucleus**) 100–10; "Granes" (**granum**) 10–1; "Rugues" (**rugatus**) 1–0.1; "Pulvres" (**pulvis**) 0.100–0.010; "Plastes" (**plasticity**) 0.010–0.001; "Moves" (**movere**) 0.0010–0.0001. (The last group showing Brownian movement.) Each primary group is divided into three secondary groups, having the prefixes "mega," "meso" and "micro," which refer to the 10–5, 5–2, and 2–1 parts of each primary group respectively, thus:—"megaplastes" (0.010–0.005), "mesoplastes" (0.005–0.002), "microplastes" (0.002–0.001). LOUIS NAVIAS

36. Japanese acid clay (fuller's earth), its properties, chemical applications and the relation to the geological formation of petroleum. KIUHEI KOBAYASHI. *Kôjin Kwagaku Zasshi* (*Eng. Chem. J.*), **1**, 15–23(1921).—A summary of the properties of the clay, the place of production, its applications in the chem. industries, and its relation to the geol. formation of Japanese petroleum. Cf. *Jour. Am. Ceram. Soc.*, **4**, 503(1921). K. K. (*C. A.*)

37. The physical chemistry of the crystallization and magmatic differentiation of igneous rocks. III. J. H. L. VOGT. *J. Geology*, **29**, 515–39(1921); cf. *C. A.* **15**, 2813, 3808.—This section is devoted largely to the discussion of the difference between the soly. of the ferromagnesian silicates in acid and basic magmas. W. F. H. (*C. A.*)

38. Note on the green color of tungsten trioxide WO_3. J. A. M. v. LIEMPT. *Z. anorg. allgem. Chem.*, **119**, 310–12(1921).—The green color is due to a slight reduction of WO_3, probably to W_2O_5. This was shown by mixing samples of WO_3 with 1% of oxalic acid and allowing to stand a week in the light and in the dark. The reduction goes on more rapidly in the light and the presence of 1% of W_2O_5 or less will account for the green color. The conclusion is that the green color is probably due to the reduction by org. matter, *i. e.*, dust, and is furthered by light. P. E. BROWNING (*C. A.*)

39. Merwinite, a new calcium magnesium orthosilicate from Crestmore, California. ESPER S. LARSEN AND WILLIAM F. FOSHAG. Wash., D. C. *Am. Mineral.*, **6**, 143–8

(1921).—This mineral, which is named after H. E. Merwin, occurs in abundance in metamorphic limestone, having previously been mistaken for monticellite. It is intimately associated with spurrite and an unidentified mineral, called "A." It is apparently monoclinic, showing polysynthetic twinning and has $\alpha = 1.708$, $\beta = 1.711$, $\gamma = 1.718$, sign + and $2V = 66\frac{1}{2}°$. There is perfect cleavage on (010); H. = 6, sp. gr. = 3.150; colorless to pale greenish, with vitreous luster, or greasy when intimately mixed with the other minerals. Material for analysis was sepd. with heavy solns., and was found under the microscope to contain less than 2% of admixture. It dissolves in HCl and gelatinizes. Analysis gave: SiO_2 35.50, 35.84, Al_2O_3 0.66, FeO_3 none, CaO 49.96, 49.70, MgO 11.62, FeO 1.23, loss at 110° 0.12, ign. 0.94 (part of the last 2 items being bromoform used in sepn.) sum 100.02%. This corresponds closely with 3 $CaO.MgO.2SiO_2$ or $Ca_3Mg(SiO_4)_2$. It alters readily to secondary minerals often appearing as a white coating or crack filling; one of them, thaumasite, has already been described (*C. A.*, **14**, 1948). The compd. does not appear in any of the CaO-MgO-SiO_2 systems which have been studied thermally, and is probably a low temp. form, breaking down below its m. p. Its association with wollastonite shows it to have crystd. below 1190°, but its occurrence suggests still lower temps. It is not closely related to any known mineral, differing from the olivine group in crystn. E. T. W. (*C. A.*)

Refractories and Furnaces

40. Eastern Steel Company new blast furnace. Richard Peters, Jr. *Blast Furnace Steel Plant*, **10**, 113–6(1922). E. J. C. (*C. A.*)

41. Discussion on the disintegration of blast-furnace linings. R. M. Howe. *Blast Furnace Steel Plant*, **10**, 161–3(1922).—Analyses are given of deteriorated linings in which no Zn was found, although the action of the linings was similar to those before. There was an increase in potash, carbon and other substances. Cf. F. W. Lurmann, *Stahl u. Eisen*, **18**, 168(1917); E. Firmstone, *Trans. Am. Inst. Mech. Eng.*, **34**, 437(1903); Bernhard Osann, *Stahl u. Eisen*, **23**, 823(1903); R. M. Howe, *Bull. Am. Inst. Mech. Eng.*, **1920**, 5. W. A. Mueller (*C. A.*)

42. Disintegration of blast-furnace linings. P. O. Menke. *Blast Furnace Steel Plant*, **10**, 116–8(1922).—Experience at the Shenango Furnace Co. plant, Sharpeville, Pa. shows that in a number of cases, furnace linings have so expanded as to cause bursting of the furnace shells. These linings were ordinarily found to be vitrified and of good character for a penetration of 2–4 in., then a softening of the brick took place which often carried to within 4 or 5 in. of the outer steel shell. The deterioration was to such an extent as to make the removal of the lining possible by hands when the vitrified portion had once been removed. This "softened" portion contained up to 50% Zn in the form of both oxide and metal. The make of brick, whether hand made or steam pressed makes no difference in this penetration action of the zinc. The action of the Zn seems to be cumulative and even with small amts. this takes place.
W. A. Mueller (*C. A.*)

43. A type of natural draft melting furnace. II. Chas. Vickers. *Brass World*, **18**, 49–52(1922); cf. *C. A.*, **15**, 3061.—Detailed erecting directions are given. For brass melting furnaces, bricks of medium coarse grain with a good strong burn are best. The six standard shapes of fire-brick and stack construction are discussed.
W. H. Boynton (*C. A.*)

44. The preparation of zirconia from Brazilian ore and a new method of determination. E. C. Rossiter and P. H. Sanders. *J. Soc. Chem. Ind.*, **40**, 70–2T(1921).—Soln. of Brazilian ore is best effected by fusion of ore ground to flour fineness with an equal quantity of NaOH in an Fe crucible with continuous stirring until the mass be-

comes granular, after which the heat is maintained at dull redness for 2 hrs. The fused mass is extd. with water, then with HCl. The insol. residue equals about 20% of the ore and contains: 61.55% ZrO_2, 29.32% SiO_2, 1.10% Fe_2O_3, 1.80% Al_2O_3, 5.90% loss on ignition. The soln. contains Zr oxychloride, Fe, Al, Ti, Mn, etc. It is dild., treated with satd. SO_2 soln. and heated to boiling. Sufficient N H_2SO_4 is added to replace the Cl in the oxychloride; Zr is deposited as basic sulfate, easy to filter, though very bulky. It is washed by decantation. ZrO_2 recovery is made by drying and igniting, or by suspending in water, treating with alkali, washing, drying and igniting the hydroxide. The ZrO_2 contains 98–99% ZrO_2, some SiO_2 and Al_2O_3 and less than 1 part of Fe in 100,000. Properties of the basic sulfate and oxychloride are given. To det. of ZrO_2 in presence of Fe and Al 7 cc. H_2SO_3 and 2 cc. H_2SO_4 are used for each 0.2 g. of ZrO_2. The soln. should be dild. to 150 cc. for each 2 cc. of H_2SO_4. Difficulty due to formation of H_2SO_4 in the reaction is overcome by boiling, after the addition of SO_2 soln. until Fe is completely reduced. Complete separation from Fe_2O_3 is obtained in proportions up to 1 : $3^1/_2$ but, with larger proportions of Fe the basic sulfate is slightly soln. in the $(NH_4)_2SO_4$ and NH_4Cl formed during neutralization. W. H. B. (*C. A.*)

45. Fusibility of open-hearth slag containing titanium dioxide. GEO. F. COMSTOCK. *Chem. Met. Eng.*, **26**, 165–6(1922).—Basic open-hearth furnace slags varied in solidifying point from 1085° to 1385° but in both cases the addn. of TiO_2 lowered the fusion point. The amt. added was at first 0.33% to correspond to the quantity which the usual addn. of 3 lbs. of Fe-Ti per ton of steel might bring into the slag. It had no distinct effect. 1.33% and 2.67% gave solidification points of 1055° and 1025°, resp., with the more fusible slag. The less fusible slag had its softening point lowered 80° by 2.67% TiO_2. TiO_2 makes basic open-hearth slag more fusible whether oxidizing or reducing conditions prevail. JAS. O. HANDY (*C. A.*)

PATENTS

46. Furnace and method of conveying materials. HARRY P. MCCANN. U. S. 1,400,367, Dec. 13, 1921. In a fur. heated by gases of combustion, a heating chamber with a hearth having a longitudinal slot therein and a work-moving member disposed in the slot; the slot is wider than the work-moving member which forms clearance spaces between the work-moving member and the walls of the slot; a flue in the hearth connected to the slot conducts the waste gases of combustion away from it. C. M. S., JR.

47. Basic refractory brick. SPENCER B. NEWBERRY. U. S. 1,400,087, Dec. 13, 1921. The process of making basic refrac. brick by calcining a mixt. of lime and argillaceous matter in such proportions that the resulting clinker will not disintegrate after long-continued heating or an exposure to air; adding to the clinker a mixt. of lime and argillaceous matter of greater fusibility than the clinker; molding the mixt. into blocks and burning the blocks at approx. the temp. used in burning ordinary fire-brick. C. M. SAEGER, JR.

48. System of kilns. LEROY WEEKS. U. S. 1,404,412, Jan. 24, 1922. A pair of kilns, each being equipped with an annular heat chamber disposed in the walls of the kiln, above the surface of the ground; a subterranean passage from one kiln has its outlet disposed between the two kilns; a flue communicates with the outlet of the subterranean passage and with the heat chamber of one of the kilns through the side wall thereof. C. M. SAEGER, JR.

49. Apparatus for burning bricks. WILLIAM WALLACE DICKINSON, JR. U. S. 1,403,300, Jan. 10, 1922. Apparatus for burning bricks comprising, in combination, a traveling crane, a row of kilns located beneath the crane (the kilns having a scoving consisting of rectangular panels of heat resistant material), and means carried by the crane whereby the panels may be transported bodily from kiln to kiln. C. M. SAEGER, JR.

50. Apparatus for burning bricks. WILLIAM WALLACE DICKINSON, JR. U. S. 1,403,301, Jan 10, 1922. A row of brick kilns combining an automatic coal stoking device movably supported at each side of the row and adapted to be presented to the kilns sucessively in heating relation. C. M. SAEGER, JR.

51. Tunnel-kiln. GEORGE W. BOOTH. Canada 1,403,734, Jan. 17, 1922. A tunnel kiln has an air space formed in its walls extending longitudinally of the preheating, firing and cooling zones of the kiln; a fur. communicates with the interior of the firing zone of the tunnel adjacent the cooling zone; a stack adjacent the inlet end of the preheating zone; a flue communicates with the interior of the firing zone of the tunnel and extends along the preheating zone of the fur. to the stack; a flue forms a communication between the stack and the air space aforesaid adjacent the inlet end of the tunnel. C. M. SAEGER, JR.

52. Rotary kiln. JOHAN SIGISMUND FASTING. Denmark 1,404,381, Jan. 24, 1921. A rotary kiln with a clinker cooling device includes an annular chamber concentric with the kiln; it is open at one end and communicates at the other end with a chamber at the end of the kiln and into which the clinker is discharged; the clinker travels through this chamber longitudinally. Means is provided to introduce into the open end of the annular chamber cooling air in excess of that required for combustion in the kiln; the escape of an excess of air from the chamber at the end of the kiln is also provided. C. M. SAEGER, JR.

53. Kiln furnace. FRANK M. MARRIS. U. S. 1,407,288, Feb. 21, 1922. The combination of a kiln with fuel and draft openings having a single integral frame and openings corresponding with the fuel and draft openings; a vertically pivoted auxiliary door inside of the vertically pivoted door; means actuated by opening the vertically pivoted door for swinging the lower edge of the horizontally pivoted door outward. C. M. SAEGER, JR.

54. Continuous kiln. WALTER G. DE STEIGNER. U. S. 1,407,192, Feb. 21, 1922. The combination in a continuous kiln having a substantially horizontal middle portion and downwardly directed end portions; means for moving a series of mechanically unconnected and separated articles to be treated by intermittent successive steps up one end portion across the middle portion and down the other end portion; means for independently supporting the separated articles during the interval between stepped movements. C. M. SAEGER, JR.

55. Furnace roofs. H. L. CHARLES. U. S. 1,394,470, Oct. 18. An integral structure of highly refractory material such as a SiO_2, lime, fire-clay, MgO or chromite compn. is molded over the fire-brick arched roof of furnaces such as reverberatory smelting furnaces and is baked by the action of the furnace gases. (*C. A.*)

56. Refractory article of magnesia and alumina. R. C. PURDY, M. F. BEECHER AND A. A. KLEIN. U. S. 1,394,442, Oct. 18. A bonded material suitable for lining furnaces or making refractory receptacles is prepd. by mixing pre-shrunk granules of one of the ingredients, MgO or Al_2O_3, with the other of these 2 ingredients in finely divided condition and heating the mixt. to a temp. somewhat below the m. p. of any eutectic of the MgO-Al_2O_3 system to effect bonding. (*C. A.*)

57. Rendering furnace walls impervious to gases. C. M. SHIPMAN. U. S. 1,387,739, Aug. 16. Furnace walls are rendered impervious to the passage of hot combustion gases by treating the walls with a slurry formed of clay, SiO_2 and sol. silicate and then exposing the treated walls to hot combustion gases. (*C. A.*)

58. Dry gas-cleaning tower. F. R. MCGEE AND G. W. VREELAND. U. S. 1,396,767, Nov. 15. The tower comprises superposed dry cleaning and filtering chambers having filtering mats with vibrating mechanism to clean the mats. (*C. A.*)

59. Oven adapted for burning ceramic ware. S. TROOD. U. S. 1,393,650, Oct.

11. The oven has a long heating chamber through which the articles to be heated are carried and comprises zones of approx. uniform temp. with intermediate zones of changing temp. The oven may be heated by gas or other fuel. (*C. A.*)

60. Heating blocks for fireless cookers. E. T. YOUNG. U. S. 1,391,037, Sept. 20. Blocks which have the heat-retaining qualities of soapstone are formed by blending kaolin with a pulverized fired kaolin and firing the mixt. at a high temp. Equal amts. of No. 9 Edgar's ball clay and No. 15 mesh fire-brick grog may be used, fired to cone No. 7. (*C. A.*)

61. Blowpipe adapted for heating, welding or cutting. G. L. WALKER. U. S. 1,395,537, Nov. 1.

Abrasives

PATENT

62. Abrasive for grinding and smoothing glass. W. L. KANN. U. S. 1,387,649, Aug. 16. Glass is ground and smoothed preparatory to polishing by the action of particles of cryst. or similar abrasive material which is broken down into successively smaller and smaller cryst. particles during the grinding and smoothing operations. (*C. A.*)

Stoneware, Whiteware and Porcelain

63. Scumming of whiteware and the peeling off of glazes. ANON. *Sprechsaal*, **54,** 429(1921).—In whiteware there is often a tendency for the glaze to peel off especially along the edges. This is due to sol. sulphates which are more abundant along the edges than other places. This scum prevents the glaze from sticking to the body and hence the glaze has a tendency to peel. By the use of $BaCl_2$ or $BaCO_3$ the scumming and hence the peeling of the glaze may be prevented. H. G. SCHURECHT

64. The insulation of high-voltage transmission lines. Conception of a million volt line. F. W. PEEK, JR. *Gen. Elec. Rev.*, **25,** 111–9(1922).—Porcelain is the only material available at present for high potential insulators. C. G. F. (*C. A.*)

BOOK

65. Die Porzellan-Isolatoren. G. BENISCHKE. Berlin: Julius Springer. 94 pp. M 24. **Die Geschichte der Porzellanfabrik zu Tettau.** LEIPZIG: Eulen-Verlag. 64 pp. M 10. (*C. A.*)

PATENT

66. Mixture for making bricks. J. SMITH. U. S. 1,385,757, July 26. A mixt. for brick making is formed of cement, coal ashes and brick dust in about equal amts. (*C. A.*)

Heavy Clay Products

PATENTS

67. Building tile and wall made therefrom. LEONARD H. DE FERNELMONT. U. S. 1,409,284, March 14, 1922. A wall composed of a plurality of tiles directly interlocked both in a vertical direction by immediate contact and in a lateral direction by means of ribbed and grooved interengaging parts on the respective adjacent edges of the abutting tiles; the adjacent edges on each side of the interlocking portions of abutting tiles are provided with grooves, the grooves outwardly flaring and opening on the faces of the wall and between the abutting tiles; cement fills the grooves to form a sealed joint between the tiles and a smooth outer continuous surface in the plane of the tiles and holds the tiles from tilting out of their common plane of alignment. C. M. S., JR.

68. Open-end hollow tile for wall structures. MATHIAS DOCHNAL. U. S. 1,406,354, Feb. 14, 1922. A building tile for wall structures comprising an inner wall section

and an outer wall section, and a pair of spaced cross-walls which unite the inner and outer wall sections; each of the cross-walls have concaved faces which form a circular central opening in the tile and a semi-circular opening at each end of the tile; a pair of opposed ribs, which extend into the central opening from the inner and outer wall sections, the ribs each having a beveled inner face uniting with the concaved faces of the cross-walls to strengthen the inner and outer wall sections midway their length; facial ribs are arranged in opposed relation at the extremities of the inner and outer wall sections and each of the ribs have a beveled inner face terminating with the ends of the concaved faces of the cross-walls. C. M. SAEGER, JR.

69. Wall construction and brick therefor. ROBERT F. MARTIN. U. S. 1,400,893, Dec. 20, 1921. A brick for wall construction comprising a solid face portion; an inner portion of spaced-end sections constituting with the face portion the wall-supporting portions of the brick; an intermediate portion comprising a lateral web which connects the end sections intermediately with their upper and lower surfaces, and provided intermediately between its longitudinal edges and its upper and lower sides with relatively narrow non-mortar receiving ribs. C. M. SAEGER, JR.

70. Drier for use in the manufacture of articles from tender clay. THOMAS L. MYERS. U. S. 1,403,440, Jan. 10, 1922. Drying app. of the kind described for use in drying articles of tender clay. This consists (1) in a drying room, a plurality of tracks therein to receive the trucks loaded with clay articles to be dried, (2) means to radiate heat to the clay articles on the trucks without air current drying tunnels; (3) means over which the trucks are thereafter moved to the drying tunnels for complete drying in a current of heated air. C. M. SAEGER, JR.

71. Tool for handling tiles. ALBERT A. CLYMER. U. S. 1,401,046. Dec. 20, 1921. A tile rolling tool with a handle and with long arms which are practically straight and parallel to each other and some distance from each other. These arms extend laterally. They have bearing surfaces to permit the tile to roll while engaged by the tool, one of the arms being adjustable relatively to the other arm for the purpose specified; the handle is bent intermediate to its end to provide the first arm, the adjustable arm has a socket; the sockets are slidably engaged with the handle, and individual means to secure the sockets to the handle. C. M. SAEGER, JR.

72. Automatic tile-cutter. NOEL C. WHITNEY. U. S. 1,400,473, Dec. 13, 1921. In a machine for the purpose specified, there is a combination of a pair of endless carriers arranged side by side with their inner runs parallel; a series of supporting members mounted on the carriers; when on the adjacent runs of the carrier these members support the material being operated upon; a series of cutting devices mounted on the carriers and adapted to operate upon the material is supported by the members during the travel thereof. C. M. SAEGER, JR.

73. Building block. ARTHUR G. HATCH. U. S. 1,408,733, March 7, 1922. A building block which has a plane face, the opposite face carrying convex cylindric flanges adjacent to the opposite edges of the block; the axis of the cylindric of the flanges are parallel to the plane face and parallel to the adjacent edge of the block. C. M. SAEGER, JR.

74. Arch-brick. ALFRED H. WILLET. U. S. 1,401,022, Dec. 20, 1921. A pair of brick members each having support-engaging parts and brick engaging parts at opposite ends; the brick engaging parts are substantially counterpart and substantially complementary and arranged with respect to each other; the support engaging parts make the brick members variable as to effective length to fit different spacings of supports; the brick engaging portions coöperating to provide reciprocal support for the adjacent ends of the members throughout the range of adjustment. C. M. SAEGER, JR.

Glass

75. Historic optical glasses. P. NICOLARDOT. *Le Verre*, **2**, 29–32 (1922).—Dollard in 1755 made the first achromatic combination for a lens, using crown and flint glasses. This new use for flint glasses caused a demand for homogeneous heavy lead glasses, with the result that a number of men attempted to make them. Prizes offered by the (French) Academy of Sciences helped to sustain interest. Much credit is due to Pierre-Louis Guinand who made radical changes in the methods of making optical glass in his day. Among other improvements was the introduction of stirring. This was accomplished by stirring the molten glass with a clay thimble thus insuring a glass having the same index of refraction throughout. About 1805 Fraunhofer and Guinand worked together at Benedictbeuren. Later Guinand's son and Bontemps divided the prize given by the (French) Society for the Encouragement of National Industry, for having perfected a method of producing good quality flint glass on a commercial scale. Both men used the methods of the elder Guinand. Through the younger Guinand and Bontemps there have been developed two of the large modern European firms making optical glass. From Guinand through a number of partnerships has resulted the French firm of Mantois, now known as Parra. Bontemps, for political reasons, was obliged to leave France, and in 1848 he joined the Chance firm in England, introducing to them the methods of making optical glass. The German firm, Schott, founded in 1882, without doubt followed Guinand's methods. LOUIS NAVIAS

76. Lime in glass batches. ANON. *Pottery Gazette and Glass Trade Review, The Glass Worker*, **41**, No. 26, 11–12 (discussion at meeting).—Action depends on form of alkali and form of lime used and ratio of lime to soda. In tanks using 8% lime, soda-ash-burnt-lime melts fastest and saltcake-burnt-lime melts slowest. In 12% lime glass, slaked-lime with either soda-ash or saltcake or both, melts fastest. Small amounts of magnesia aids melting. R. J. MONTGOMERY

77. Use of cullet in melting glass. ANON. *Pottery Gazette and Glass Trade Review, The Glass Worker*, **41**, No. 26, 12 (discussion at meeting).—Up to 50% cullet aided in melting, plaining and uniformity. Above this amount, glass is hard to free from bubbles. 33% recommended. R. J. MONTGOMERY

78. Glass decoration (lecture before the "British Pottery and Glass Trades"). J. T. FEREDAY. *The Glass Worker*, **41**, No. 26, 18.—General method of cutting, engraving, intaglio and cameo cutting, etching and color decoration is given. R. J. MONTGOMERY

79. Action of metallic lead in pots. HENRY W. HESS. *The Glass Worker*, **41**, No. 28, 14.—Metallic lead was put in a pot holding 150 lbs. of litharge batch. The melt was clear, there was no action on the pot bottom and no trace of metallic lead in the glass. Six trials gave the same result. R. J. MONTGOMERY

80. Liquid inclusions in glass. CHARLES E. BENHAM. *Geol. Mag.*, (March) **1922**; *Nature*, **1922**, April 8, 456, **1922**.—A glass tube about 3″ long and 1/4″ external diam. was partly filled with water and sealed. It was enclosed within an unbaked brick and fired in a brick kiln at about 1200°C. After this treatment the glass was found to contain microscopic liquid inclusions with vapor bubbles comparable to those found in quartz. WM. M. CLARK

81. Dispersion in optical glasses. III. F. E. WRIGHT. *J. Optical Soc. Am.*, **5**, 389–97(1921); cf. *C. A.*, **14**, 3135; **15**, 2343.—A table is given based on the conclusions of the 2 previous articles from which by arithmetical interpolation the mean dispersion and the corresponding partial dispersions can be read off directly to the 5th decimal place. The table is tested by series of fluor crowns, borosilicate crowns, barium crowns, flints, borosilicate flints, and barium flints. The errors found are commonly restricted to the 5th decimal place. "The chief optical differences in glasses are not differences in

the character of the dispersion, but in the fact that 2 glasses may have the same dispersion relations and yet have appreciably different abs. refractive indices. In a dispersion formula both refringence and dispersion should be specifically recognized; the first as a const. giving the datum level of refringence and the second as a function of one or more terms expressing the run of dispersion throughout the visible spectrum. These conclusions follow directly from the analysis of the linear relations which have been shown to exist between the partial dispersions of a series of optical glasses. They prove that a rise in the partial dispersion at any part of the spectrum is accompanied by a corresponding rise in partial dispersions over the entire visible spectrum."

G. E. BARTON (*C. A.*)

82. Automatic vial necking and bottoming machines. J. F. SPRINGER. *Glass Ind.*, **2**, 266–9(1921); 2 illus.—In the necking machines the necks are formed on pieces of tubing of a size for 2 vials one end at a time, the pieces being fed twice through the machine. The bottoming machine takes these tubes and seals off the center, forming the bottoms of the otherwise completed vials. J. B. PATCH (*C. A.*)

83. The electrical properties of glass. J. R. CLARKE. *Glass Ind.*, **2**, 221–3(1921).—Cf. *Ceram. Abs.*, **5**, 48(1922). J. B. PATCH (*C. A.*)

84. Steam gage glasses. J. F. SPRINGER. *Glass Ind.*, **2**, 240–3(1921); cf. *Ceram. Abs.*, **5**, 81(1922).—S. suggests greater tolerance in specifications for steam gage glasses with use of a proper washer, utilization of the waste tubing for lubricator tubes and the possibility of tooling the ends of the tube to meet specifications. J. B. PATCH (*C. A.*)

85. The effect of temperature upon the ultraviolet absorption of glasses. W. RIEDER. *Jahrb. Phil. Fak. II, Univ. Bern.*, **1**, 148–54(1921).—Twelve varieties of glass were studied at temps. up to 450° and in one case down to the temp. of liquid air and with wave lengths down to 2250 Å. All exhibited a transmission limit below which the transmission for all shorter wave lengths was zero. Increase of temp. in all cases raised this transmission limit toward the region of longer wave lengths. The data are recorded in the author's thesis ms. in 48 tables. E. W. W. (*C. A.*)

86. Free alkalinity in glass containers. A. W. BITTING. *Glass Ind.*, **2**, 235–7 (1921).—The results of 72 tests of typical bottles from various sources and of different shapes and sizes are tabulated. Flint, blue, green and amber glasses are included. The containers were filled to capacity with dil. H_2SO_4 and also distd. H_2O and allowed to stand from 1 to 48 hrs. The sol. alkali is expressed in mg. NaOH per 1. The av. results range from 0.40 mg. NaOH per 1. from a 250-cc. bottle to 26.64 and 33.92 mg. per 1. obtained from a 5-cc. container. The effect of standing 2 weeks is just about to double the original reading and after that the increase proved to be very slow. The results of these tests indicate that American bottles have a low free alkalinity (at variance with what has been assumed to be true for machine-made ware). The quantity is so low as to be practically neglibible for any except very delicately balanced chem. products. J. B. PATCH (*C. A.*)

87. The manufacture of glass milk bottles. A. L. BROWN. *Glass Ind.*, **2**, 259–62 (1921).—A detailed story from raw materials and their handling through the melting and gathering of the glass to the sorting and packing of the finished product. A typical batch for milk bottles is: sand 2,000, soda ash 750, lime 250, niter 21, Mn 12–35 (av. 16), powdered blue 2 ounces. J. B. PATCH (*C. A.*)

88. Graded seal for joining pyrex to lead glass. W. C. TAYLOR AND AUSTIN BAILEY. *J. Ind. Eng. Chem.*, **13**, 1158(1921).—The seal consists of five glasses of Pb-free borosilicate compn., intermediate between pyrex and Pb-glass, which are all comparatively stable and can be worked repeatedly without devitrification. The range in softening point varies from 817° to 623° and the linear expansion coeff. from 0.0000032 to 0.0000089 per degree. GEO. W. STRATTON (*C. A.*)

PATENTS

89. Method and apparatus for drawing sheet glass. FERNAND E. DEULIN. U. S. 1,411,079, March 28, 1922. In a glass-drawing app. in which a sheet of glass is drawn vertically and then bent over a bending roll, a gas pipe with a longitudinal series of perforations, placed closely above and substantially parallel with the roll, so that a continuous series of flames from the perforations will play on the horizontal run of the sheet as it leaves the roll. C. M. S., JR.

90. Glass-cutting mechanism. HARRY S. DEPUTY. U. S. 1,407,736, Feb. 28, 1922. In a sheet glass scoring device, an axial support, a cutter mounted on the support, means for adjusting the cutter longitudinally of the support, and means for adjusting the support and cutter circumferentially, both means being operative from one end of the support. C. M. S., JR.

91. Glass-cutting table. HARRY M. BARBEAU. U. S. 1,410,153, March 21, 1922. In a glass-cutting table, a stationary guide measure, a slidable guide measure, a slidable stop coöperating with each guide measure, means for securing the slidable stops in fixed position, and means the position of which is limited by the slidable stops for detg. the line along which the glass is to be cut. C. M. S., JR.

92. Frost and obscuring condensation preventative for glass surfaces and method of preparing the same. PHILLIP SHERMAN. U. S. 1,410,839, March 28, 1922. A frost and obscuring-condensation preventive for glass surfaces, comprising a piece of fibrous material treated with a mixt. of mineral oil, vinegar, water and calcium chloride. C. M. S., JR.

93. Method and apparatus for marvering glass. DAVID E. GRAY AND FRANK E. BARDROF. U. S. 1,410,803, March 28, 1922. In a glass-working app., the combination with a main frame, of a blow-pipe carrying frame mounted for movement in the main frame, a marvering roller mounted for movement on the blow-pipe frame toward the blow-pipe and for a tilting movement in respect thereto, resilient means tending to move the roller, control mechanism on the main frame normally free from the roller, but adapted to be operatively engaged therewith by the movement of the blow-pipe frame, and when put into engagement therewith, adapted to first release the roller for movement toward the blow spindle and for then releasing it for its tilting movement; and means including the blow-pipe for rotating the marvering roller. C. M. S., JR.

94. Heat-resisting iron-chromium-nickel alloy. J. T. GLEKLER. U. S. 1,389,133, Aug. 30. An alloy adapted for glass molds or furnace parts is formed of Cr 15–40, Ni 1–15 and Fe to make a total of 100 parts, with small amts. of Si, Ti, Mn and C. (*C. A.*)

95. Muffle oven for decorating or annealing glass or enamel ware. C. E. FRAZIER. U. S. 1,389,583, Sept. 6. See *Ceram. Abs.*, **5**, 75(1922). (*C. A.*)

96. Glass-covered steel rolls. K. MATSUO. U. S. 1,394,684, Oct. 25. Rolls adapted for printing patterns on cloth are formed of steel pipe, the outer surface of which is smoothed and covered with a layer of milk glass which is rich in metallic constituents such as to give it about the same coeff. of expansion as steel. (*C. A.*)

97. Glass containing mica or asbestos. P. B. CROSSLEY. U. S. 1,394,973, Oct. 25. Mica or asbestos is dissolved in molten glass at a temp. below that at which the mica effloresces, to obtain an *elec. insulating material.* (*C. A.*)

98. Glass composition. E. E. FISHER. U. S. 1,394,296, Oct. 18. A glass adapted for the manuf. of baking or lab. dishes is formed of SiO_2 60–90%, B_2O_3 3–15%, oxides of Mg, Zn or Ba 3–15%, Al_2O_3 0.5–5% and oxides of Na, K, Li or Rb 6% or less. *C. A.*

99. Daylight glass. D. N. MACDONALD. U. S. 1,393,804, Oct. 18. Finely ground

Co-blue glass is thinly spread over and fused into the glass diffusing of enclosures for incandescent lamps to absorb excess red and yellow rays. (*C. A.*)

100. Glass working—glass—metal joints. H. WEISS. *Brit. Pat. Appl.* 174,925. *Ill. Off. Jour. Pats.*, **629,** March 29(1922).—An air tight joint for an anode is formed by metal coverings sprayed or deposited by electrolysis on the anode insulator, and comprises hollow rings having slits and containing a pliant material which melts when heated and passes into the slits so as to seal the joint; the metal covering extends over the hollow rings. Sketched. WM. M. CLARK

101. Aluminum, tungsten, and other oxides, alkali aluminates, tungstates, etc. J. D. GAT. *Brit. Pat.* 174,908. *Ill. Off. Jour.*, **622,** March 29(1922).—Describes equipment for preparing compounds of metal oxides with alkalis, such as aluminate or tungstate. Chlorine and sodium are liberated in the app. by electrolysis of fused NaCl, the sodium then reducing the clay, kaolin, bauxite, orthoclase, spodumene, etc., used. WM. M. CLARK

102. Method of and appliance for polishing glass and the like substances. WILLIAM TAYLOR. England 1,409,888. The method of controlling the supply of liquid lubricant in the polishing of a surface by means of a polishing member. This member and the work are moved relatively to one another to effect the polishing, which method comprises utilizing the variation of frictional resistance between the surfaces of the work and polishing member to effect variation of the supply of lubricant. C. M. S., JR.

103. Machine for angular grinding spectacle glasses. OTTO HENKER. Germany 1,409,546, March 14, 1922. In a machine intended for angular grinding spectacle-glasses of non-circular shape, a plane cam, a stop, a grindstone, and a shaft designed for holding the spectacle-glass, the cam coöperating with the stop and being disposed on the shaft, which is free to oscillate about an axis by which it is intersected perpendicularly and the axis of the grindstone crossed perpendicularly. The stop is rotatable about an axis, which is parallel to the axis of oscillation of the shaft and at variable distance from it. It lies in the plane detd. by the axis of oscillation and by the point which the angular edge of the spectacle glass has in common with the grinding surface. The cam is displaceable longitudinally on its shaft and is compelled by the stop to permanently contain in its plane the axis of rotation of the stop, on the shaft which is rotated. C. M. SAEGER, JR.

104. Apparatus for feeding molten glass. KARL E. PEILER. U. S. 1,405,936, Feb. 7, 1922. In an app. for sepg. molten glass into mold charges, the combination of a glass container having a submerged outlet, a reciprocating air pump arranged to create pressure and vacuum on alternate strokes, a conduit connecting the pump and the surface of the glass, a pressure relieving valve and a vacuum relieving valve in the conduit, a cam for opening each valve, means for relatively adjusting the cams, and means for independently adjusting the rate at which normal pressure is restored by each valve. C. M. SAEGER, JR.

105. Method of and apparatus for finishing blown-glass articles. DAVID E. GRAY. U. S. 1,409,847, March 14, 1922. In a device of the character described, the app. with a bulb-carrying mechanism has periods of rest at a plurality of stations; a burner is located at one of these stations and adapted to preheat a narrow zone around the neck of a bulb at such station; a burner located at a succeeding station and adapted to re-heat such pre-heated zone to cause the neck to elongate, and to puncture the elongated neck and sever the same. C. M. SAEGER, JR.

106. Glassware-ejecting mechanism. EDWARD H. LORENZ AND KARL E. PEILER. U. S. 1,406,045, Feb. 7, 1922. A glass shaping machine having a plurality of traveling molds with bottom valves, ware-ejecting means including a reciprocatory plunger,

and mechanism adapted to force the plunger against the bottom valve of each mold in succession and thereby eject the contents of the molds while traveling. C. M. S., Jr.

107. Carrier for glass articles. Henry F. Clark. U. S. 1,405,757, Feb. 7, 1922. A carrier for glass shawls, comprising a movable frame adapted to be suspended from and travel upon an overhead track, said frame having supporting means for a plurality of the shawls, and spacers or separators movably mounted on the frame and adapted to sep. and space adjacent shawls, substantially as described. C. M. Saeger, Jr.

108. Ware steadier for glassworking machines. James W. Lynch. U. S. 1,406,400, Feb. 14, 1922. A device for preventing glass articles from being forced to either side of a mold having separable sections as the mold opens, the device including a movable stop having adjustable fingers adapted to embrace an article centrally positioned in the mold, and means for periodically moving the stop into a working position in which the fingers are about, but spaced from the upper portion of the article before the mold opens. C. M. Saeger, Jr.

109. Glass-plate manufacture. Albert A. Icenhour. U. S. 1,407,036, Feb. 21, 1922. In a process of making sheet-glass, drawing the sheet from a molten mass of glass in a container approx. the width of the sheet so that the edges of the sheet at the points of formation of the sheet travel down the interior of the wall of the container during the drawing operation, the container being tapered at opposite sides to cause the adhering edges of the plate to travel in vertical lines down the vertical channels formed by the tapering of the walls of the container. C. M. Saeger, Jr.

110. Grinding or polishing of glass and apparatus therefor. Frank Edwin Slocombe. England 1,404,553, Jan. 24, 1922. An app. for grinding or polishing plate glass, the combination with two opposed discs with grinding or polishing faces in parallel or nearly parallel planes and two horizontal shafts on which the discs are respectively mounted, the shaft being nearly parallel and out of line sufficiently to secure effective grinding or polishing at the centers of the discs, of means positively to rotate one disc, and sucker devices to secure the glass to be ground to a disc surface. C. M. S., Jr.

111. Glass cutter. Walter W. Ratcliff. U. S. 1,402,961, Jan. 10, 1922. A rotary glass cutter, comprising a base, a standard thereon having a laterally projecting portion terminating in a vertical head, a stem mounted for rotation and for vertical adjustment in the head, a cutting member carried by the lower end of the stem, a spring exerting a downward pressure on the stem, and means for raising the stem and cutting member against the influence of the spring. C. M. Saeger, Jr.

112. Mechanism for forming glassware. William J. Miller. U. S. 1,400,621, Dec. 20, 1921. In a machine for manufacturing articles of glass, the combination of forming means, a carrier intermittently revolving in a vertical plane beneath the forming means, and a plurality of molds pivotally mounted on the carrier and adapted to be presented in turn to the forming means, the pivotal axes of the molds being above their centers of gravity whereby the molds normally retain their upright position. C. M. Saeger, Jr.

113. Sheet-glass-drawing mechanism. Robert P. Callard. U. S. 1,402,145, Jan. 3, 1922. A combination with a split demountable rim adapted to assume a collapsed state in its inoperative position, a double elbowed toggle having its outer ends connected to the end portions of the rim, one of the toggle links having a limited movement with respect to the toggle and disposed to overlap the rim. C. M. Saeger, Jr.

114. Glass-cutting machine. John A. Milliken. U. S. 1,402,457, Jan. 3, 1922. In a glass cutting mechanism of the character described comprising a chuck, a grinder, means for alternately moving the grinder into and out of engagement with an article to be operated upon, and a feeler member reciprocated to and from the article by corresponding movements of the grinder. C. M. Saeger, Jr.

115. Machine for the manufacture of glass articles. ROBERT FREDERICK HALL. England 1,408,939, March 7, 1922. A machine for blowing hollow glass articles including, (1) supporting frame, (2) a parison mold carried thereby, (3) means for actuating the parison mold which includes a member movable in a plurality of directions relatively to the supporting frame, (4) a knife adapted to be swung in an arc beneath the parison mold, (5) a vertically extending member on which the knife is carried, (6) means including a sleeve feathered on the vertically extending member and having a crank connected with horizontally reciprocable means for rotating the vertically extending member to effect the swinging movement of the knife beneath the parison mold, (7) bearings having a universal movement on the frame and on the relatively movable parison mold actuating member in which the vertically extending member is journaled, the vertically extending member also being slidable vertically in the bearing on the frame, whereby the knife is maintained in proper position irrespective of the relative movement of the parison mold actuating member. C. M. SAEGER, JR.

Enamels

116. Enameling cast-iron and steel materials. F. L. PRENTISS. *Iron Age*, **109**, 13–16(1922).—This paper describes the methods and app. used in enameling cast-iron and steel tanks, etc., at the plant of the Elyria Enameled Products Co. The article is well illustrated. DONALD E. SHARP (*C. A.*)

117. Enameled-products research laboratory. EMERSON POSTE. *Chem. Met. Eng.*, **25**, 974–7(1921).—The lab. and equipment are described and methods of control and research are briefly given. E. H. (*C. A.*)

Cement, Lime and Plaster

118. A compression test machine for cements. GUILLERY. *Rev. Mat. Constr. Trav. Pub.*, **147**, 240(1921).—(Read before the French and Belgian members of the International Association for Testing Materials.) This is an inexpensive machine for compression strengths of cement cubes of 5 cm. side and of concrete cylinders 10 cm. high and 10 cm. in diam. To a base plate is bolted a cylindrical support carrying a screw head at the top and worked by hand. A large piston with $^3/_4$ mm. play, slides inside the cylinder, a layer of rubber between them affording a tight fit. The compression chamber is placed in the base where the piston and its cylinder are suitably fitted into each other. The upper end of the piston is fitted with a removable copper support for the test piece. This support has a permanent large holder for catching the disintegrated fragments. The upper support for the cube has a slightly spherical face and is inserted into the screw head above. A compression pump, operated by hand and attached at one side, forces glycerine into the compression chamber and under the piston. A manometer indicates the pressure of the liquid. An adjustable safety valve limits the pressure, and a discharge valve relieves the pressure at the end of a test. The manometer carries three scales, the first giving the total pressure, the second giving resistance per sq. cm. on a cube of 5 cm. side, the third giving the resistance per sq. cm. for a concrete cylinder 10 cm. high and 10 cm. diam. With the piston in its lowest position, the screw is brought down on to the test piece, then the discharge valve is closed and the pump put into operation until the piece breaks. The resistance may then be read directly from the scale. A round plate 10 cm. in diam. constitutes the upper support fitted into the screw for crushing concrete cylinders. LOUIS NAVIAS

119. Chemico-technical and mechanical testing of caustic magnesite. R. POCHE. *Baumaterialien-Markt*, No. 36 and 38, **1921**. Reprint.—Since the value of burned magnesite as a building material can not be detd. from its chem. anal., the following tests

are necessary: I. *Sieve test.*—The residue remaining on 80 and 130 mesh sieves is detd., together with the wt. of a l. of the sieved material. No values are given. II. *Setting time.*—100 gm. magnesite are mixed for one min. with 40–52 cc. 20° Bé $MgCl_2$ soln. and poured out on a glass plate. The hardness is detd. with the Vicat needle app. The cake should be covered to prevent rapid drying. The setting time should be 2–5 hrs. III. *Expansion test.*—3 pts. by wt. of magnesite are mixed with 1 pt. of pine sawdust and moistened with 20° Bé $MgCl_2$ soln. The sawdust particles should be 50%–0–1 mm. and 50%–1–2 mm. in diam. A stick of the mixt. $^1/_2$–1 m. long is pressed out and allowed to set, being protected from drying. At least a month is required to attain const. length, although the first 10–14 days will give a good indication of the amt. of change. By the end of two weeks the linear expansion should not be $> 0.15\%$ or the contraction $> 0.25\%$. The air around the test piece must have a rel. humidity of $60 \pm 6\%$. IV. *Tensile strength.*—The test piece is made of the same material used in the expansion test. After 3 days the tensile strength should not be < 8 or > 25 kg./cm.^{2} after 7 days, not < 20, after 56 days not < 40 kg./cm.^{2}

E. N. BUNTING

120. Blast-furnace cement. H. BURCHARTZ. *Mitt. Materialprüfungsamt,* **38,** 163–182(1920).—The investigation was made to det. whether blast-furnace cement might be safely used in construction work in which the German government was interested. Six blast-furnace cements were analyzed and tested. The best and the poorest of these were compared with 2 portland and 2 iron portland cements. The tests included mortars and reinforced concrete; they lasted from 1914 to 1919. The blast-furnace slag mortars and concrete were as strong as those from portland cement. The blast-furnace cements contained 60–75% of slag. This was detd. by dividing the total sulfide S by that found in the part of the cement remaining on a 100-mesh sieve and of lower sp. gr. than 2.98. The sulfide percentages in the slags varied from 1.49 to 3.02 and were 2.42 in the weakest and 2.71 in the slag in the strongest cement. MgO in the weakest cement was 1.98% and in the strongest 2.81%. SiO_2, 27.7% and 26%, resp., Al_2O_3 and Fe_2O_3, 9.98% and 12.60%. CaO, 53.22% and 51.88%. SO_3, 1.14% in both. Undetd., 1.80 and 1.33%. The crushing strength of mixts. by wt. of 1 part cement and 3 of sand (normal) averaged for blast-furnace cement mix, 5401 lb. per in.^{2}; iron portland cement mix, 5473 lb.; portland cement mix, 4995 lb. per in.^{2} After 2.5 yrs., 1:4 mixts. by wt. showed, resp., in reinforced concrete, 7008, 7037 and 7867 lb. per in.^{2} The larger part of the admixture was a graduated one of sand and gravel. Mixts. of 1 part by wt. of cement and 5 parts of raw sand showed a crushing strength of 6000 lb. after air and water exposure for 5 yrs. and 4700 lb. per in.^{2} if in water all the time. There was no recession in strength in any of the blast-furnace cement mixt. The German government authorized the use of blast-furnace cement on government work. Cf. *Ceram. Abs.*, **5,** 50(1922).

J. O. H. (*C. A.*)

121. Plastic calcined magnesite and oxychloride cements. M. Y. SEATON. *Chem. Met. Eng.*, **25,** 233–6(1921).—The history, chem. compn. and the usual source of the raw materials of oxychloride cements are given. The following physical tests are discussed: strength, vol. change, setting, time, resistance to water and the influence of the character of the aggregate. Suggested specifications include: fineness—97% through a 100-mesh sieve, 75% through a 200-mesh sieve; setting time (plastic oxychloride mortar)—initial set not less than 1 hr., final set not more than 8 hrs.; modulus of rupture (on bars $^1/_2$ in. thick 2 in. wide and 24 in. long)—not less than 550 lb. per sq. in. at 1 day and 100 lb. per sq. in. at 7 days; expansion or contraction not less than 0.3% within 24 hrs.; wet strength should be at least 30% of dry strength. See *Ceram. Abs.*, **5,** 88(1922).

J. C. WITT (*C. A.*)

122. The successful recovery of potash as a by-product from cement kilns. C.

KRARUP. *Chem. Met. Eng.*, **25,** 316–20(1921).—The recovery of potash at the plant of the Santa Cruz Portland Cement Co. is described. Several new features have been introduced. J. C. WITT (*C. A.*)

123. Judging the quality of portland cement. R. J. COLONY. *Trans. Am. Inst. Mining Eng.*, **1921,** No. 1088, 3 pp.; See *Ceram. Abs.*, **5,** 51(1921).—A reply to discussion. C. N. WILEY (*C. A.*)

124. Action of lime in magnesium oxychloride cements. M. Y. SEATON, C. R. HILL AND L. C. STEWART. *Chem. Met. Eng.*, **25,** 270–4(1921).—The influence of active lime (CaO or $Ca(OH)_2$) on Mg oxychloride cements is discussed. Methods of detg. the amt. of active lime present on agitation with H_2O and detn. of alkalinity with phenolphthalein indicator; agitation with 5% NaCl soln. and detn. of alkalinity with methyl orange indicator; agitation with $MgCl_2$ soln. and detn. of $CaCl_2$ in the soln. Comparable results were not obtained by the use of the 3 methods. A relation between active lime content of calcined magnesites and physical properties of the oxychloride cement produced from them is brought out. This relationship is apparent only when av. results from many samples are considered. Other factors may completely obscure the relation in a test on a single sample. Active lime content is accordingly not a definite indication of poor quality in a magnesite, although a magnesite contg. active lime in large amt. should be regarded with suspicion. Physical tests of oxychloride cements must still be regarded as the only safe criterion of the quality of magnesites used in the oxychloride industries. J. C. WITT (*C. A.*)

125. An outline of the uses of lime. M. E. HOLMES. *Chem. Met. Eng.*, **26,** 294–300(1922). E. J. C.

PATENTS

126. Magnesium oxychloride cement. J. L. TUFTS. U. S. 1,386,914, Aug. 9. A dry cement material is produced by agitating calcined magnesite in a closed vessel while introducing into the material sufficient HCl gas and H_2O vapor to produce a product in the proportions of 5 MgO, 1 $MgCl_2$, 5 H_2O. (*C. A.*)

127. Plaster composition. C. NOLL. U. S. 1,393,814, Oct. 18. Plaster for use on walls or ceilings is formed of $Ca(OH)_2$ 20, clay 15, sand 40 and a porous material such as blast-furnace slag 25 parts. (*C. A.*)

128. Increasing plasticity of calcined gypsum. W. E. EMLEY. U. S. 1,392,574, Oct. 4. Calcined gypsum is ground in a ball mill to eliminate the H_2O content during the grinding operation but the H_2O is prevented from escaping and is permitted to be reabsorbed before the completion of the grinding in order to obtain a finely ground product of good plasticity. (*C. A.*)

129. Liquid ceramic pastes. E. WEBER. U. S. 1,394,241, Oct. 18. Ceramic pastes which are difficultly liquefied with alkali are treated with saponin to facilitate liquefaction in order to improve the pouring and molding properties of the material. Quillaja or senegin also may be used for the same effect. (*C. A.*)

130. Cement. WALTER T. GODDARD. Canada 1,409,091, March 7, 1922. A cement compn. containing an inert non-friable element initially coated with an elastic substance. C. M. SAEGER, JR.

131. Multiple brick mold. FRANK J. KINZINGER. Canada 1,406,460, Feb. 14, 1922. A multiple mold for concrete bricks and the like comprising end plates, a series of interposed longitudinal mold forming members each including a verticle base plate, and a series of right angle plates secured in contiguous alignment on the base plate, and means for securing the end plates and the mold forming members together. C. M. S., JR.

132. Method and machine for forming impressions in plastic articles. JOHN LAPP. U. S. 1,407,550. Feb. 21, 1922. A method of forming impressions in plastic articles which consists in gyrating a forming tool about the axis of the surface to be im-

pressed but without rotation about its own axis and gradually varying the radius of the tool's gyration. C. M. SAEGER, JR.

133. Concrete-tie-making machine. JOHN NELSON. U. S. 1,400,969, Dec. 20, 1921. A tie-making machine comprising cement feeding app.; movable mold jaws adapted to receive the cement from the feeding app.; automatic operating means for the jaws adapted for engaging the cement during operation, and means adapted for positioning a reinforcing member between the jaws for embedding in the finished tie. C. M. SAEGER, JR.

134. Method of producing a cold glaze for building materials, in particular cement. KARL FRIEDRICH. Germany 1,402,412. Jan. 3, 1922. A method of producing a cold glaze consisting in mixing a finely sifted, sandfree building material with an emulsion of water containing bituminous substances free of volatile oils and oxidized in the presence of alkalis. C. M. SAEGER, JR.

135. Means for use in the manufacture of concrete roofing tile. WILLIAM THOMAS COWPERTHWAITE. New Zealand 1,403,940, Jan. 17, 1922. The combination of a pallet adapted to support in a horizontal position a plate of plastic material and having a flange forming portion having an aperture therein; a pin adapted to project through the aperture during the molding operation and to be withdrawn after the molding operation has been completed; a bearing frame beneath the pallet; a slide mounted thereon; a rod mounted on the side slide to which the pin is fixed; a spring controlling the rod and keeping it in position to withdraw the pin from the aperture; a main shaft; a lever arm pivoted beneath the pallet and having its end engaging the back end of the rod; and means whereby the lever arm may be turned to push the rod outwardly, the means being controlled by the operation of the main shaft. C. M. SAEGER, JR.

136. Heat insulating and resisting material. EDGAR T. HOLMBERG. U. S. 1,404,438, Jan. 24, 1922. A heat insulating and resisting material made by moistening a mixture of about 30% magnesia and 70% of an infusorial siliceous earth with a saturated solution of magnesium chloride and compressing such moistened mixture in a mold. C. M. SAEGER, JR.

137. Building-block. CHARLES C. WORTHINGTON. U. S. 1,400,709, Dec. 20, 1921. As a new article of manufacture, a building block comprising a rectangular body of stonelike material cast with horizontal rectangular cavities formed by a plurality of vertical cross walls, which are disposed perpendicular to the face of the block and also by vertical longitudinal back walls forming the backs of the cavities, one of the vertical walls being a partition wall between adjacent cavities, each of the walls being of uniform thickness and a fictile nailing material cast in position in each of the cavities to be exposed on the surface of the wall constructed of such blocks. C. M. SAEGER, JR.

138. Cement-block machine. CLEMENT ZOPHY. U. S. 1,408,558, March 7, 1922. A machine of the class described comprising a supporting structure including vertical standards having their intermediate portions vertically recessed, a mold box mounted on the supporting structure, a removable pallet closing the bottom of the mold box, a slide block slidably mounted in the recess of each standard, a transverse channel beam carried by each slide block, a supporting member carried by each connected together slide block and channel beam, shafts journaled adjacent the ends of the channel beams, lifting arms carried by the shafts, roller means carried by the outer ends of the lifting arms and tracking in the channels of the beams, and means for simultaneously rotating the shafts in opposite directions to raise the pallet above the mold to permit the stripping of a block which has been formed in the mold box. C. M. SAEGER, JR.

BULLETIN

of the

American Ceramic Society

A Monthly Publication Devoted to Proceedings of the Society, Discussions of Plant Problems, Discussions of Technical and Scientific Questions and Promotion of Coöperative Research

Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

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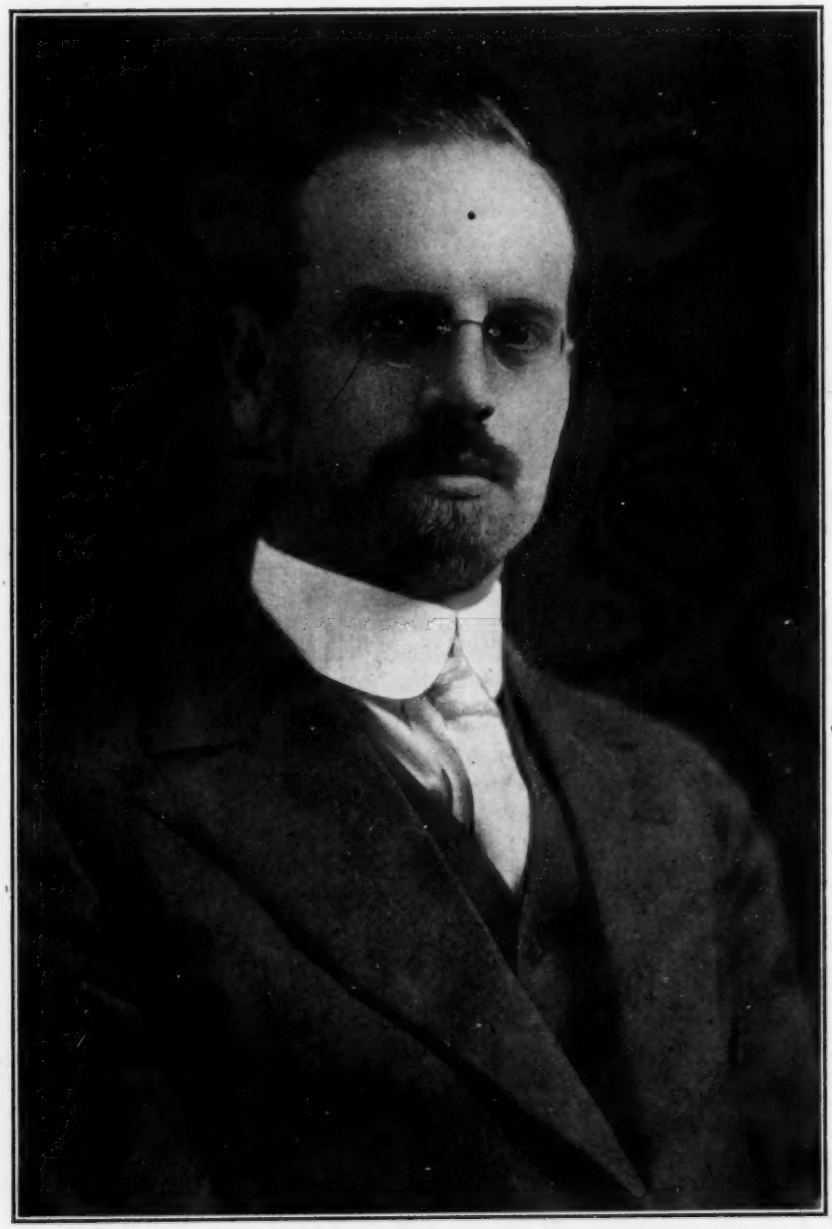
Vol. 1 **July, 1922** **No. 3**

EDITORIALS

DR. EDWARD W. WASHBURN

A Sketch and a Tribute

For six years Dr. E. W. Washburn has been the directing head of the department of Ceramic Engineering at the University of Illinois and during the past year he has been editor-in-chief of the *Journal of the American Ceramic Society*. During these six years he has contributed to ceramic science from the viewpoint of a physical chemist with a peculiar gift for searching and proving fundamentals. His laboratory at the University is equipped with devices that are unusual to ceramic laboratories but the discoveries there made have been told by Dr. Washburn in such an elementary fashion that most of us have not an adequate appreciation of the ingenious methods and painstaking thoroughness by which he has derived fundamental facts, concerning which ceramists have long been theorizing from empirical observations. One must study his contributions and know something of the methods used to appreciate the value of that which Dr. Washburn has contributed during these six years. Only thus can an estimate be made of the loss which ceramic science will feel because of his withdrawal from this special field. His new work takes him to Washington, D. C., where he will be editor-in-chief of "International Critical Tables of Physical, Chemical, and Engineering Constants," and chairman of the Division of Chemistry and Chemical Technology of the National Research Council.



E. W. WASHBURN

The present editor of this *Journal* confidently expresses for all members of the Society sincere gratitude to Dr. Washburn for his contributions to ceramic science and especially for the services he efficiently rendered as member of the Research Committee during the past four years and as editor of this *Journal* during 1921. It is hoped that the Society will be favored by a continuance of his interest and assistance in the things it aims to accomplish. He enters into a broader field of science with the best wishes of every member of this Society.

We recite here from "Who's Who" a résumé of what he has achieved: Chemist: Univ. of Nebr., 1899–1901; Mass. Inst. Tech., B.S. 1905, Ph.D. 1908; Research assoc. in physical chemistry, Mass. Inst. Tech., 1906–08; Assoc. in chem., 1908–10, Assist. prof., 1910–13; Prof. physical chem., 1913–16; Prof. ceramic chem., and head of dept. of ceramic engineering, 1916–22; U. of Ill. Editor-in-chief Internat. Critical Tables of Phys., Chem. and Engrng. Constants, 1922—Vice-chmn. and acting chmn., 1918–19 Chmn. 1922–23, Div. of chem. and chem. tech., Natl. Research Council; Delegate to Internat. Union Pure and Appl. Chem., London, 1919, Lyons, 1922 and to Internat. Research Council, Brussels, 1919 and 1922; Amer. Commissioner Internat. Annual Tables of Phys. and Chem. Constants, 1921. Fel. A.A.A.S., Mem. Am. Chem. Soc., Am. Phys. Soc., Am. Ceramic Soc. (Ed. "Jour." 1921), Nat. Research Council, Soc. Glass Technology, Roy. Soc. Arts; Ill. Acad. Sci., Phi Lambda Upsilon, Sigma Xi, Mass. Soc. Mayflower Des., Colonial Families. *Author:* Introduction to the Principles of Physical Chemistry, McGraw-Hill Book Co., New York, 1915, 2nd. Ed. 1921, French translation by Noyes and Weiss, Payot et Cie, Paris, 1922; sixty contributions to scientific and technical press embodying results of original research. *Clubs:* Cosmos, Washington, D. C., Chemists, N. Y., University, Urbana, Ill. *Address:* National Research Council, Washington, D. C.

His researches and publications are:

A. Introduction to the Principles of Physical Chemistry.

The McGraw-Hill Book Co., New York. 1915. Pp. xxv + 445. 2nd. Edition 1921. Pp. xxvii + 500.

1. The Theory and Practice of the Iodometric Determination of Arsenious Acid. *J. Amer. Chem. Soc.*, **30,** 31 (1908).

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TWO NOTABLE EVENTS MARK PROGRESS IN CERAMIC ENGINEERING

Edward Orton, Jr. Made Doctor of Science
New Jersey Ceramic Research Station Building Dedicated

Rutgers College honored itself and gave recognition to Ceramic Engineering as an applied science when on June 13th it conferred the degree of Doctor of Science upon Edward Orton, Jr. and dedicated a handsome and well-equipped building to the teaching of, and for, research in Ceramics.

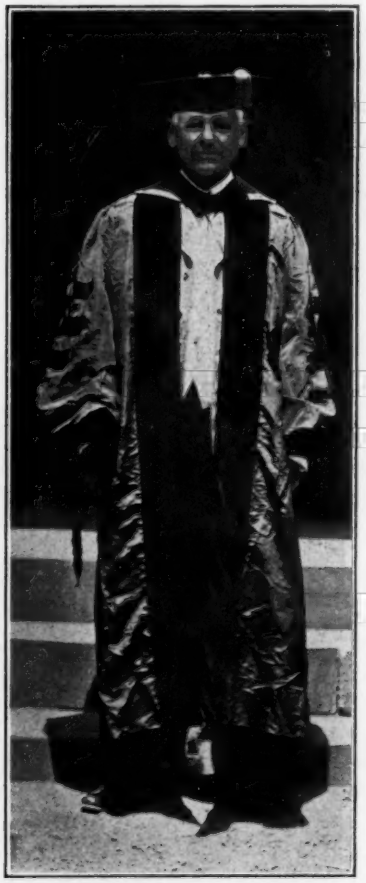
For over 150 years Rutgers College has maintained an enviable research record in the classics and in the pure sciences and no deviation was made from her traditional conservatism when she in this substantial manner recognized Ceramics as a science.

Prof. George H. Brown.

For twenty years Rutgers College has been offering courses of instruction in Ceramics and maintaining ceramic research laboratories. These twenty years have been years of substantial accomplishments in Ceramic technology and of increasing recognition and support of scientific and technical research by the Ceramic industries.

In 1894 the first collegiate course of instruction in Ceramic Engineering was opened to students at the Ohio State University under the directorship of Edward Orton, Jr. Four years later the American Ceramic Society was organized by him. In rapid succession similar courses of ceramic instruction and ceramic research stations were established in the states of New York, New Jersey,

Illinois, Iowa, Oregon, North Dakota, Washington and in Saskatoon, Canada, in federal bureaus, and in several European countries. Societies for the promotion of Ceramic arts and sciences have been established in England, France, Germany and Japan. The Dean of this world-wide organization for the promotion of ceramic arts and sciences is our own Edward Orton, Jr., who for twenty years was secretary of the American



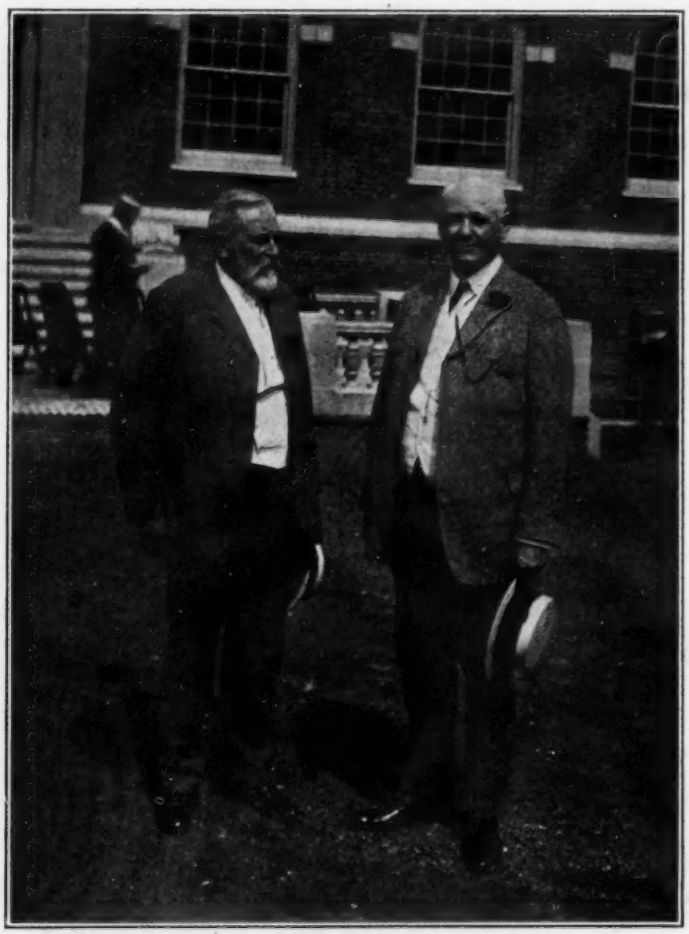
Edward Orton, Jr., E.M., D.S.

Albert V. Bleininger.

Ceramic Society. It was very fitting, therefore, that Rutgers College with its 150 years of traditions should, on the 20th anniversary of the establishing of its own ceramic department, give recognition and honor to him to whom belongs the credit for initiating this world-wide promotion of Ceramic technology and science.

Left to right: Abel Hansen, Charles H. Cook, Frank H. Riddle, Dr. W. H. S. Demarest, Prof. George H. Brown, Roy H. Minton.

Prof. George H. Brown is the Director of the New Jersey Ceramic Research Station. To him belongs the lion's share of credit for obtaining the handsome and well appointed building on Rutgers campus. He was loyally supported by the New Jersey Clay Workers under the



Charles A. Bloomfield. Dr. Edward Orton, Jr.

leadership of Charles A. Bloomfield, Charles H. Cook, Abel Hansen, August Staudt, past presidents of the New Jersey Clay Workers Association, and by Roy H. Minton, the present president. $100,000 was given by the State and the equivalent of $30,000 was contributed by the clay workers.

The purposes of this Ceramic Research Station are:

1. To give instruction in Ceramic Engineering and in Ceramic Arts and Sciences.
2. To conduct Extension Courses in Ceramics in different centers throughout the State.
3. To Conduct Coöperative Industrial Researches.
4. To investigate the resources of the State ceramic materials.
5. To publish Ceramic literature.

We confidently bespeak for the Ceramic workers the world around a self-congratulation that the State of New Jersey has so well equipped herself for the training of ceramists and for the prosecution of ceramic investigations. These facilities, though they will be maintained by New Jersey, will be an addition to the facilities of the entire ceramic craft the world around.

THE VALUE OF DISCUSSIONS

Growth: the Interchange of Ideas.—Since the founding of the American Ceramic Society the custom of the Annual Meetings has been to carry on the activities of the Society through the medium of *Discussions*. The need for this interchange of ideas was, in fact, the fundamental reason for the organization of the Society. If everyone had felt complete master of his work, with no difficulties to encounter and no problems to solve, each would have continued to go his separate way content. There would have been no desire for lengthy trips which meant time lost and money and energy expended. And in the end this narrow, ingrowing spirit would have meant a retrogression and serious crippling of business. *Isolation does not encourage progress.*

The reason, then, for these meetings was the need felt by the scientific man and the practical business man to get together and contribute to the experience of others as well as to accept their share. Each one recognized his limitations and sensed the value of the ideas of the others. This interchange of ideas has always stood for growth and in the Society it meant development from a few score of men to many hundreds.

Thoroughness of the Early Years.—But with the increase in membership in the Society new difficulties arose. In the early days, when the number was small, the men knew each other intimately and their problems took on the aspect of personal difficulties. Each one was considered at length and thoroughly discussed. In the older volumes of the *Transactions*, all of the members were active participants in these discussions. They were intimate and companionable, and yet, informal as they were, the results were far-reaching and conclusive. A problem was not left until the solution was made as complete as these men could work it out.

If a definite end could not be obtained, the discussions were continued throughout the year by correspondence and the questions were reconsidered at the next Annual Meeting. Thoroughness characterizes these discussions as they appear now in the *Transactions*.

Discussions Supplement Annual Meeting.—Necessarily, with the remarkable increase in the Society membership, the attendance at the meetings has become a matter of hundreds rather than the few score as at first. The affairs of the Society demand more time; there are more problems, but no more time. One of the most frequent expressions during the progress of a heated discussion is "This must be continued at another time." There are many other papers to be heard; many other questions of just as vital importance to be taken up and probably left unfinished. And then the meeting is over. A few copies of the Reports are circulated among the officers. Otherwise, the questions discussed are dead issues, the solutions of problems lost.

This, then, is the first purpose of opening the pages of the *Bulletin* to the members for Discussions. There is the opportunity of preserving the record of the results of the meetings as well as carrying the subject much further and working out new phases and solutions. Objections may be brought up and confusing questions explained. In other words, the meeting is over, but the forum is once more open and Discussions are going full tilt.

Open Forum for the Society.—A second, but by no means less, consideration is the matter of the thousand or more members who have not been present at the meeting. They have as many problems of vital importance to work out and as many ideas of worth to offer to others but without a medium of expression their aid is impossible. With the presentation of the Discussions they are not only given the benefit of the transactions which they have missed, but they are invited to contribute to these same Discussions; to add their weight of experience. Not only to themselves but to the entire Society, these members take on a new significance for they are contributing to the welfare of the Society as well as deriving benefits from its organization. For the first time, the bulk of the Society is made to feel an active interest which hitherto has been denied. They recreated themselves into an active, working force which is ready to offer to the Society aid to the uttermost limit.

Keeps Subjects Active.—In addition to papers presented at the meetings and the discussions which follow them, there are many papers published which are received in the Editor's office not in connection with a meeting. These papers are vital and alive. Their problems and issues are current and as essential as any given consideration at the meetings. The members are losing a great deal not to use these for Discussions. The idea that a paper which was published last year is a dead issue is

fundamentally wrong. The *Journals* themselves are of more than current interest. Their scope includes subjects of interest to every member. They are current and alive until a new idea is presented to displace them.

Vitality of Discussions.—And so the *Bulletin* herewith presents the opportunity for this exchange of ideas. It is the organ of expression for the fifteen hundred members of the Society. A few score of men write the original papers which interest and demand the criticism of the entire Society. And it is in the *Bulletin* that these new voices must be heard. The *Bulletin* belongs to these fifteen hundred members in the seven Divisions, and it will become the thing they decree it to be. This is every member's opportunity to express ideas and ask questions.

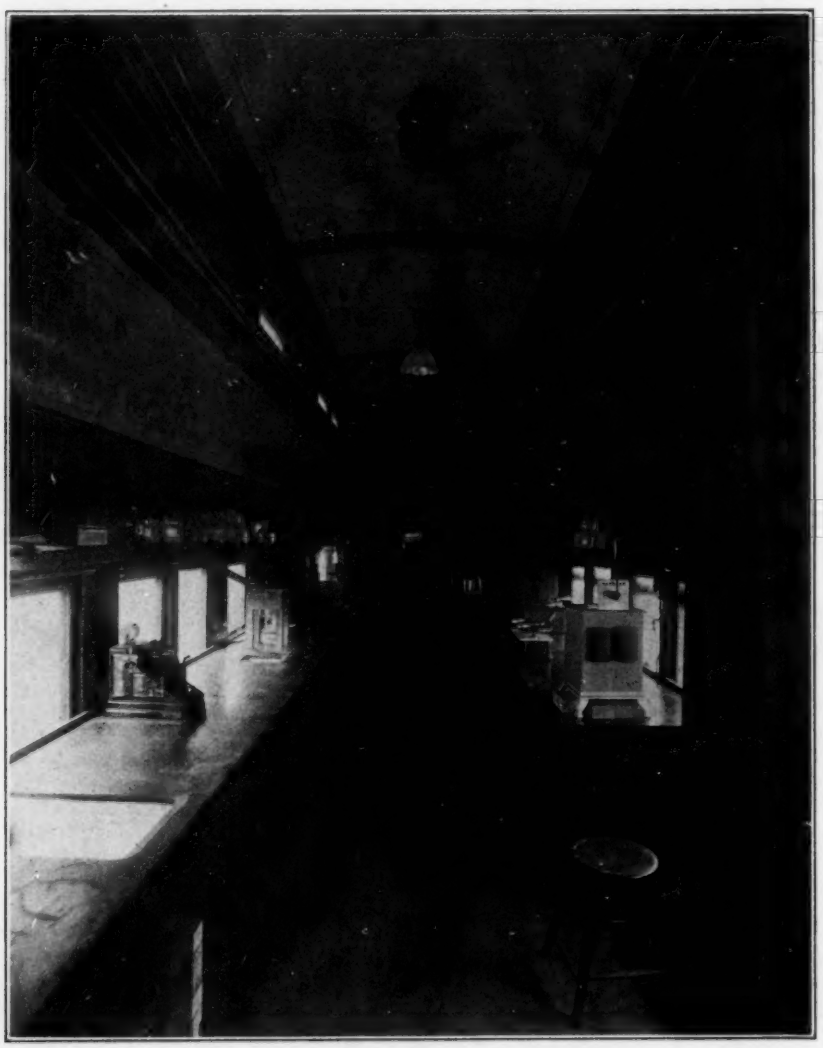
The *Bulletin* will then be vital.

ACTIVITIES OF THE SOCIETY

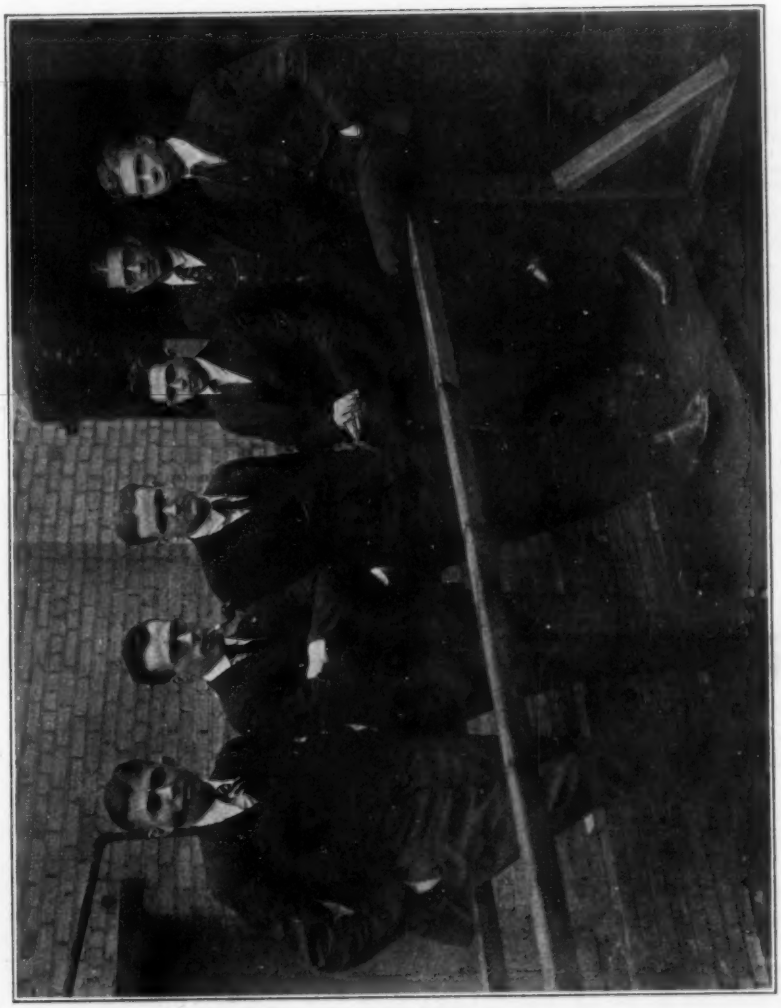
U. S. Bureau of Mines

Laboratory Car "Holmes"

The accompanying illustration shows the gang of good men and true whose duty it is to keep the "Holmes" fires burning. The car is being used to visit different brick plants in the general region of Ohio for the observation of firing methods employed and the pointing out of wasteful practices and opportunities for improvement that should



Experimental Laboratory on the "Holmes."



Crew of Laboratory Car "Holmes," U. S. Bureau of Mines. Reading from left to right: Wm. Rice, A. R. Mumford, P. S. Bachman, Robt. Lunger, E. B. Baker, R. C. Zehm.

result in the saving of fuel. Results of tests made at a brick plant in St. Louis, recently visited, show a decided saving in fuel and an improved product. At South Park, Kentucky, after preliminary burns in a type of kiln for burning hollow tile, the car superintendent was able to point out needed changes in construction and operation that should result in a decided saving of fuel and an improved product.

Ceramic Experiment Station, Columbus, Ohio

Oxidation of Ceramic Wares during Firing

It is planned in the investigation of the oxidation of ceramic wares during firing, to continue making measurements of the rate of evolution of H_2O, CO_2, SO_3, and SO_2 from clay bars (Lower Kittaning fire) in a combustion tube in a current of oxygen at various temperatures, atmospheres and typical clays. During the oxidation of "siderite" iron clays, siderite, magnetite and hematite are, at a certain stage of the burn, all present at the same time.

Georgia Clays and Bauxites

Washing tests of Georgia clays have been completed. Samples of bauxitic and refractory clays have been calcined to cone 13, ground to pass 10 mesh and mixed with 40 per cent raw clay. Samples of commercial size bricks have been completed by the dry process. When made up into a standard pottery body this clay showed none of the objectional specks common to unwashed Georgia clays and was a good color.

Dolomite Investigations

Slacking tests have been run by the Bureau of Mines on clay-dolomite, bauxite-dolomite bricks previously burned. Different dolomites are being investigated as to mechanical and chemical desirability. The highly crystalline ore has been found to crush more readily than the dense.

New Members Received during May

Associate

Allison, John H., 902 Oliver Bldg., Pittsburgh, Pa., Sales Engineer, E. J. Deckman Co.
Bowers, John, 1510 Brunswick Ave., Trenton, N. J., B. O. T. Mfg. Co.
Curry, Earl, Willoughby, Ohio, Student, Ohio State University.
Donnenwirth, Arthur L., 121 S. Spring St., Bucyrus, Ohio, Student, Ohio State University
Green, Thomas S., La Courneuve, Seine, France, Cie des Meules Norton
Kane, Edward, 1432 Riverside Drive, Trenton, N. J.
Kennedye, C. Benton, 2085 Railway Exchange Bldg., St. Louis, Mo., District Manager, Brown Instrument Co.
Parsons, F. C., Atlantic Terra Cotta Co., Tottenville, N. Y., Supt.
Roberts, Nathaniel J., Quakerstown, Pa, Gen. Mgr., Quakerstown Stove Works
Rose, Charles I., 3802 Castleman St., St. Louis, Mo., Student, University of Illinois
Schweiker, Malcolm A., 137 W. 25th St., New York City, Gen. Mgr., Empire Floor and Wall Tile Co., Inc.
Thorpe, Drew M., 1922 Oliver Bldg., Pittsburgh, Pa., District Manager, E. J. Lavino & Co.
Tokunaga, Zenshiro, 2 Chome, Yorikunachi, Osaka, Japan

Corporation

Livermore Fire Brick Works, 604 Mission St., San Francisco, Cal.
J. L. Mott Co., Trenton, N. J.

The National China Co., Salineville, Ohio
Robertson Art Tile Co., Box 848, Trenton, N. J.
St. Louis Terra Cotta Co., 5811 Manchester Ave., St. Louis, Mo.

Batter Up!

In personal memberships this month we have held our own—thirteen—(an unlucky number to stick at), but in Corporation memberships we have taken a sickening drop. Optimistic as ever, though, we have an encouraging point to bring out. Seven of the Associates and four of the Corporations came in during the last three days. We expect now to have a batting average of four a day for the next month.

Bowman 2nd and Hottinger head the batting list with two Corporation members each. Babcock, Burroughs, and Watts have two Associate members each, and Salisbury has added another to his list of Corporation members. Those who put the leather across the plate once are Christopher, Hursh, Ichijo, Klinefelter, Malm, Ogden, and Wells. This shows that some of our bush-league players are giving the old guard a chance to wonder whether they can hold their places on the team.

Here is a typical letter from a typical worker:—

"MR. ROSS C. PURDY, *Secretary*
American Ceramic Society
Lord Hall, Ohio State University
Columbus, Ohio

Dear Sir:—

Will you kindly send to Mr.———, Chemist and Metallurgist of———, a sample *Journal*, descriptive literature of the Society, and an application blank. He is interested in fire clay refractories and I would appreciate it if you would send him a *Journal* containing an article on this subject.

Yours fraternally,
(Signed)————"

We have had a letter of this kind from the same man at least twice a month since he joined the Society about a year ago. Most of these "prospects" become members and boosters in their turn.

The Membership Committee are getting into their new uniforms. O. O. Bowman 2nd, the chairman, has a beautiful wind-up, the plate has been dusted off—now get into the game!

An Umpirical Correction

The score-card of the membership game, "Play Ball," reported in the May number, was slightly balled up and off its base, as it failed to give credit to Sam Geijsbeek for two more hits, making three in all and putting him in Class 2 of the pill-pounders. Having been properly cushioned, the umpire hastens to make this announcement, with due apologies.

Geographically Speaking

The geographical distribution of the *Journal* has been the subject of study lately, and the figures compiled are given below:—

Alabama	1	Connecticut	4	Florida	1
California	55	Delaware	2	Georgia	10
Colorado	12	District of Columbia	33	Idaho	1

Illinois	146	New Jersey	160	Washington	16
Indiana	47	New York	187	West Virginia	42
Iowa	17	New Mexico	1	Wisconsin	14
Kansas	7	North Carolina	5	Wyoming	1
Kentucky	13	North Dakota	2		
Louisiana	1	Ohio	319		
Maine	2	Oklahoma	3	Australia	8
Maryland	30	Oregon	8	Canada	38
Massachusetts	40	Pennsylvania	237	England	63
Michigan	37	Rhode Island	3	France	13
Minnesota	5	South Dakota	2	Philippines	1
Mississippi	1	Tennessee	11	Scotland	7
Missouri	78	Texas	8	Japan	74
Montana	2	Utah	4	Miscellaneous	
Nebraska	1	Virginia	3	Foreign	69

Total 1845

As was to be expected, Ohio has the largest number of subscribers, with Pennsylvania as the runner-up. New York, New Jersey and Illinois are not far apart, but the rest of the states are not even on the same lap. Missourians have to be shown, of course, but surely seventy-eight is not adequate representation, and are there only four progressive ceramists in Connecticut?

Who's Where in the American Ceramic Society?

W. J. Bidleman has moved from Wellsville, Mo., to Denver, Colo., where his address is 12 Meade Apts., 200 Broadway.

H. D. Callahan of Columbus, Ohio, has taken a position with the National Fire Proofing Co. and is at present located at Port Murray, N. J.

George W. Cooper, publisher of "Glass Industry," has notified us of a change in the location of his office from 19 Liberty St. to 50 Church St., New York City.

S. F. Cox, of the Pittsburgh Plate Glass Co., has moved from Creighton, Pa., to 628 Haverhill St., Wilkinsburg, Pa.

E. E. Fisher, formerly of the Modern Glass Co., Toledo, Ohio, is now in the feldspar business at Hayesville, N. C.

R. D. T. Hollowell, secretary of the American Face Brick Association, may now be found at 130 North Wells St., Chicago, Ill., the new headquarters of the Association.

Lloyd Lamborn, editor of "Chemical Age," announces the removal of his office from East 28th Street to 381 Fourth Avenue, New York City.

Paul D. Merica, of the International Nickel Co., has changed his headquarters from Bayonne, N. J., to 67 Wall St., New York City.

Amos P. Potts, formerly with the Seguin Brick and Tile Co., at McQueeney, Texas, is now with the Clay Products Co., at Brazil, Ind.

G. R. Shelton, research fellow for the Corning Glass Works, has been transferred from the University of Illinois to the University of Saskatchewan, Saskatoon, Canada.

S. F. Walton has recently become a member of the firm of the Northern Refractories Co. at Ridgway, Pa., dealers in high grade crude and ground Pennsylvania fire clay.

Calendar of Conventions

American Association for the Advancement of Science—Salt Lake City, Utah, June 22–24, 1922

American Society for Testing Materials—Atlantic City, N. J., June 26–July 1, 1922, C. L. Warwick, Sec., 1315 Spruce St., Philadelphia, Pa.

International Union of Pure and Applied Chemistry—Lyons, France, June 27–30, 1922

National Bottle Manufacturers Association—July, 1922, C. R. Stevenson, Bus. Mgr., 120 Broadway, New York City

Annual Safety Congress of the National Safety Council—Detroit, Mich., August 28–September 1, 1922

American Chemical Society—Pittsburgh, Pa., Sept. 5–9, 1922, Charles L. Parsons, Sec., Washington, D. C.

Association of Iron and Steel Electrical Engineers—Cleveland, Ohio, September 11–15, 1922, John F. Kelly, Sec., Empire Bldg., Pittsburgh, Pa.

Eighth National Exposition of Chemical Industries—New York City, September 11–16, 1922

American Electrochemical Society—Montreal, Canada, September 21–23, 1922

National Association of Commercial Organization Secretaries—Chicago, Ill., October 23–25, 1922, John E. Northway, Sec., Hamilton, Ohio

National Exposition of Power and Mechanical Engineering—New York City, December 7–13, 1922

American Malleable Castings Association—January 10, 1923, Robt. E. Bolt, Sec., 1900 Euclid Bldg., Cleveland, Ohio

National Jewelers Board of Trade—New York City, January 18, 1923, F. C. Backus, Sec., 15 Maiden Lane, New York City

American Concrete Institute—February, 1923, Harvey Whipple, Sec., East Grand Boulevard at Moran, Detroit, Mich.

American Ceramic Society—Pittsburgh, Pa., February 12–17, 1923, Ross C. Purdy Sec., Columbus, Ohio

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Report of the Enamel Division

The fourth annual meeting of the Enamel Division of the American Ceramic Society was held at St. Louis, Mo., February 28 to March 3, in conjunction with the annual convention of the Society. There were 87 members of the Division present, a record attendance. Sixteen papers were read before the Division. These will appear in the *Journal of the American Ceramic Society* during the year. Editor Purdy has arranged for the publication of discussions by any member of the Division interested, and additional information in connection with the various papers will thus be brought out. All written discussions on the subjects of the papers will be welcomed by the Editor.

The following officers were elected for the present year:

Chairman—B. T. Sweely, Coonley Mfg. Co., Cicero, Ill.

Secretary—R. R. Danielson, Bureau of Standards, Washington, D. C.

Councilors—D. F. Riess, Vollrath Co., Sheboygan, Wis.
W. C. Lindemann, A. J. Lindemann & Hoverson Co., Milwaukee, Wis.
R. D. Landrum, Vitreous Enameling Co., Cleveland, Ohio
H. F. Staley, Metal & Thermit Corp., New York City

The following committees have been appointed for the year:

Standardization of Tests—E. P. Poste, *Chairman*, R. D. Cooke, H. N. Cox, L. J. Frost

Standardization of Products—D. F. Riess, *Chairman*, R. D. Cooke, C. A. Blackburn, B. T. Sweely

Membership—W. C. Lindemann, *Chairman*, C. M. Smoot, F. G. Jaeger, R. D. Landrum, E. E. Geisinger, H. N. Cox

Rules—J. B. Shaw, *Chairman*, R. D. Wells, B. A. Rice

Data—R. R. Danielson, *Chairman*, E. P. Poste, H. F. Staley, H. P. Reinecker

Research (Sheet Iron and Steel)—R. R. Danielson, *Chairman*, D. M. Buck, R. B. Dimmick, J. A. Aupperle, H. S. Marsh, Ernest Richardson, C. A. Blackburn, L. A. Adams

Research (Cast Iron)—R. R. Danielson, *Chairman*, W. C. Lindemann, H. R. Mills, M. E. Manson, E. P. Poste, B. B. Kahn

The various committees are now actively at work and there is every promise of the Enamel Division becoming increasingly important and valuable to those connected with the enameling industry.

A meeting of the Research (Cast Iron) Committee was held at Cleveland, Ohio, on May 11, with the entire membership of the Committee present. A comprehensive program of an investigation of cast iron for enameling purposes was drawn up at that time with particular reference to the blistering of enamels applied to cast iron. This investigation will be conducted in coöperation with the Enameled Metals Section of the Bureau of Standards, and it is hoped to interest actively all cast iron enamelers of the Enamel Division in the work through a questionnaire to be sent out by the Secretary at an early date.

The Research (Sheet Iron and Steel) Committee has planned an investigation of the warpage and buckling of iron and steel sheets in the enameled process. It is planned to conduct the preliminary studies at the Bureau of Standards, this to be followed by coöperative work in several of the enameling plants engaged in the enameling of flat sheets.

The Committee on Data has planned the preparation of an index of the enamel papers which have appeared in the *Transactions* and *Journals* of the Society. The index will probably include other information pertinent to the Division.

The By-Laws of the Division have been revised to conform with revisions in the Constitution of the Society and copies have been sent to the members of the Division for vote.

The Division now has a membership of 21 Corporation, 39 Active and 150 Associate Members.

American Ceramic Society Summer Excursion Meeting

ROCHESTER, MONTREAL, OTTAWA, KINGSTON, TORONTO, HAMILTON, NIAGARA FALLS, BUFFALO

August 13–19 inclusive

Inspection of Feldspar Mill—Enamel Plant—Glass Plant—Wall and Floor Tile Plant—Brick Plant—Hollow Ware Plants—Electric Porcelain and Abrasive Plant—and the famous Canadian Feldspar Mines at Verona.

A delightful trip by water from Rochester, N. Y., to Montreal, Quebec. The famous Thousand Islands. DAYLIGHT TRIP from Thousand Islands to Montreal. A never to-be-forgotten trip filled with beauty and thrills. Running all the rapids. **The Galops and the Rapids duPlat** are the first and least exciting, though they are bounded by wooded curves that make this stretch of the river one of incomparable wonder.

Long Sault Rapids next: The greatest of all the St. Lawrence; nine miles of seething water between cool green masses of wooded islands.

Coteau Rapids: Tortuous, winding in and out among seven miles of islands.

Cedar Rapids: the most beautiful of all.

Split Rock Rapids: Difficult to navigate.

Cascade Rapids: White crested and foaming.

Lachine Rapids: The last of the rapids, narrow, twisting, irregular.

Sounds exciting and it is!

THE SCHEDULE OF ITINERARY

Sunday—August 13th: Lv. Rochester, Boat, 10:45 P. M.

Monday—August 14th: Ar. Montreal, 6:45 P. M.

Tuesday—August 15th: Montreal.

Wednesday—August 16th: Lv. Montreal, 8:30 A. M., Ar. Ottawa, 11:30 A. M.

Thursday—August 17th: Lv. Ottawa, 10:40 A. M.; Ar. Verona, 2:34 P. M.; Lv. Verona, 6:35 P. M.; Ar. Kingston, 7:35 P. M.; Lv. Kingston, 10:30 P. M.

Friday—August 18th: Ar. Toronto, 7:30 A. M.

Saturday—August 19th: Lv. Toronto, 9:15 A. M.; Ar. Hamilton, 10:15 A. M.; Lv. Hamilton, 2:30 P. M.; Ar. Niagara Falls, 4:15 P. M.

EXPENSE OF THE ENTIRE TRIP

	Fare	Lower	Upper	Seat	Total
Rochester to Montreal	$11.55	$2.50	.....	....	$14.05
Montreal to Ottawa to Verona to Kingston	7.80	.....	.....	1.30	9.10
Kingston to Toronto	6.10	2.75	.....	....	8.85
Toronto to Hamilton to Niagara Falls	2.90	.....	.....	1.20	4.10
					$36.10

Upper Berths 50c less than lower. Drawing Room four times the Lower Berth Rate. Daily additional expense $10.00 per day. Meals and Hotel per single person.

Estimated Maximum Total Expense $100.

IMPORTANT NOTICE

EXCURSION TO ENGLAND

Owing to industrial conditions here, as well as in England, the excursion to England has been postponed until the Summer of 1923.

COLLOQUIUM[1] ON FELDSPAR AND FELDSPAR DEPOSITS[2]

(This colloquium was led by Raymond B. Ladoo, mineral technologist of the U. S. Bureau of Mines. His preliminary report on this subject, as published in the *Bulletin*, issued by the Society February 20, was the basis of this colloquium.)

The outstanding features of the present feldspar industry as given by Mr. Ladoo are as follows:

(1) Many grinding companies do not own or control all or even a major part of their sources of crude material, but buy in job lots from many sources.

(2) There is a great need of more adequate engineering and chemical control over mines and mills.

(3) Out of date, inefficient methods and equipment for mining and grinding are in common use.

(4) Little or no coöperation exists between feldspar producers, but on the contrary many feldspar companies are exceedingly secretive. This tends toward (*a*) preservation of obsolete methods; (*b*) want of knowledge of the essential features of production, market requirements, and the relation between total milling and consuming capacities of the country; (*c*) inefficient and often mistaken trade practices; (*d*) unprofitable and even ruinous competition in dull periods.

(5) The small size of many feldspar deposits precludes maintenance of an efficient organization at each individual mine.

(6) Many of the best deposits of feldspar situated close to railroads are becoming depleted, which results in gradual lowering of grades, and increase in cost for better grades.

(7) There is a lack of exact knowledge of the ceramic properties and behavior of feldspar by some consumers, which results in (*a*) purchase of feldspar on the basis of price alone, thus encouraging low production costs at the expense of quality, and (*b*) inefficient and expensive crosshauling of both crude and ground feldspar.

(8) The grinding capacity of the country greatly exceeds the consuming capacity. There are more than 25 mills with a total capacity in excess of 300,000 tons per year, for a normal consumption of not more than 150,000 tons per year.

(9) There is a lack of uniform tests, specifications and standards of quality and fineness for different uses; and lack of standard definitions of grades.

Suggestions given by Mr. Ladoo to improve the situation are as follows:

(1) Gradual replacement of all of the present mills by a small number

[1] NOTE:—Article X (10) *Constitution of the American Ceramic Society.*

The Society is not, as a body, responsible for the statement of facts or opinions expressed by individuals in its publications.

[2] White Wares Division, Annual Convention, St. Louis, March 1, 1922.

of new grinding mills designed by competent engineers and equipped with the latest and most efficient machinery.

(2) Ownership or control of sufficient deposits of high-grade feldspar by the grinding companies to supply their entire requirements.

(3) Setting up of standard grades and specifications for feldspar for all uses.

(4) Instituting of centralized chemical and engineering control over all mining and milling operations, so that an absolute check on quality may be had at all times.

(5) Close coöperation among producers and between producers and consumers in order to promote greater knowledge and confidence and a more intelligent production and utilization of feldspar.

Discussion on Feldspar

MR. LADOO:—This report was made at the request of a group of potters who came to the Bureau of Mines and asked that a thorough investigation of the feldspar industry be made. I spent nearly a year collecting the information that went into the report, and before the report was issued, I submitted it to eight or ten different people representing different branches for criticism, and all of the criticism received was incorporated into this paper, so that this paper not only represents my opinion, but the opinion obtained from various sources.

MR. SLADEK:—Did Mr. Ladoo inquire into means for increasing purity of the ground feldspar?

MR. LADOO:—I have discussed that question in reference to iron. I do not know whether a process can be worked out to eliminate iron. It has *not* as yet been done. It is a subject which ought to be investigated further.

MR. A. A. KLEIN:—I see no reason why there should not be some method devised to do away with these iron particles.

MR. SPURRIER:—The question of separating iron from feldspar is not alone a question of separating iron by magnets. You may thus purify the feldspar as much as you can, getting all the iron out that is practical, and some will still be left. I have seen a magnetic separator used by potters with both good and poor results. There is one thing to be remembered, no matter how well you make the separation, nothing will ever give you absolutely iron-free materials when using the magnetic separator alone. You are almost certain to get free iron in your material simply from the mechanical handling. If your maintenance gang is working in proximity, it is not certain they will not let some iron drop into what you are handling. In any case a potter cannot be excused for not using some sort of separator. I think the best place for the magnetic separator is in the slip, but even

here I do not think you will ever get complete removal of the iron. To do it most effectively, your layout has got to be very big, and that involves a very big item of expense.

MR. LADOO:—I think an improvement could be made in some mills by putting in a magnetic separator between the coarse crusher and the fine grinder, to remove iron which comes from the crusher plates, and thus do away with some of the iron which is bound to get into the product from handling. I think that can be done very well in some cases at least. In some processes magnetic materials are removed by magnets. I have heard in the past year of two or three installations of a process that would remove a considerable amount of such materials, but I very much doubt if even that process can economically give a pure enough product.

MR. JOS. P. RODGERS:—I have been in the business a number of years. About a year ago, a large manufacturer made a number of tests producing a sample that looked pretty good. I ordered a carload and ground one half of it through a Hardinge mill; the other half through an out-of-date apparatus, and then had the two products analyzed. In about fifty analyses during the past year this quarry has shown an iron content averaging .18%. In the tests that we made of the feldspar after grinding from two different forms of apparatus, there was not a difference of 0.01% between the two feldspars. We had three analyses made of the Hardinge mill grind, and three analyses made of the granite chaser grind.

I wish to read a discussion of Mr. Ladoo's report which I have written.

Mr. Ladoo has undoubtedly presented many points of merit, yet from my own viewpoint, I am unable to see that we have been given anything that will materially assist us to give the manufacturer of Ceramic products a better material at a better price. I am not in a position to speak for other millers, and can only judge from what we are doing and in the light of my own experience, which has extended over nearly 30 years. It seems to me that Mr. Ladoo has been unduly severe in his criticism of our end of the game.

The condition of the feldspar business in 1920 was a temporary one, due entirely to the fact that 90% of the business men of the country lost control of their labor, lost their heads and made a wild plunge for profits. The feldspar miller was not alone in this respect, but his capacity for doing damage was greater, and for that reason, he is better remembered.

So far as the ownership of mines is concerned, I was under the impression that most of the old line millers, either owned or controlled considerable deposits. I know there are a number of millers who do not control mines, but these people are doing business because of the philanthropy of the feldspar consumers and, having no responsibility, dump the onus of their errors on other millers who have sins enough of their own.

So far as engineering and chemical control is concerned, we are doing

what Mr. Ladoo says we ought to do, and then some. Our Company uses 150 gallons of kerosene each month to operate a testing furnace. We have a complete set of test screens and use them daily. We employ a reputable chemist to keep us posted on the composition of our crude materials, and the man in question had two years practical experience in work of our character before he began to do our analytical work. It is true, as Mr. Ladoo says, that we do not do this work at our mine. We do it in a chemical laboratory where naturally, one would expect it to be done.

As to the series of paragraphs on inefficiency at mine and mill, I think you will grant that what is efficient and what is not, is largely a matter of opinion, yet I cannot help but feel that Mr. Ladoo has picked out for his "horrible examples" one or two radical instances which could hardly be considered as typical of the industry. Surely the concern which required six handlings at its mill is not one of the country's large millers. At our principal deposit the feldspar is mined in an underground shaft, and when it is broken it is loaded into a skip or mine car, hauled out of the mine and dumped on to a grizzly where it is sorted either for a truck to the railroad or a cart to the refuse dump. When the car reaches the mill, the feldspar is forked into crude feldspar bins and from there it is wheeled either to a large crusher or to a chaser mill.

We are not dependent entirely upon what Mr. Ladoo terms an out-of-date style of mill, nor have we adopted, I am glad to say, all of the innovations shown on his flow sheets. In one department we have an old type chaser mill and a finish mill and in another we have the large and small crushers, the conical mill and finish mill. The last named operations are far more efficient than the chaser mill, but some of the largest users in the country will not buy feldspar that is handled through a rock crusher, and the conical mill cannot be adequately fed without one. As I have said, we have them both; you "pay your money and take your choice."

A few weeks ago a competitor asked my advice on the proposition of installing a rotary dryer such as Mr. Ladoo suggests. He had been quoted $2800 for the dryer, and the motor, shafting and cost of installation would add $700 more. I happened to know that he could cover the floors of his crude feldspar sheds with a steam pipe pan and install a boiler to produce his steam all for $900 and the cost of operating the outfit would be about the same as the operating cost of a rotary dryer, consequently, we could not see the advisability of that part of Mr. Ladoo's plan.

In another place the capacity of the Improved Feldspar mill is placed at 4 tons per hour. The most feldspar we are able to force into a 22-inch mill is 4500 pounds per hour.

The 30-inch mill has an advertised capacity of 10% greater than the 22-inch mill. I submit that it would be a difficult problem to take more out of the mill than you can put into it.

One of our competitors recently bought a much advertised air separator. It is said that he bound the selling company to secrecy before he placed his order, and that he has whispered to consumers the supposed fact that because of this separator, "all your feldspar troubles are ended now, henceforth and forever." Various forms of air separators have been sneaked into feldspar mills to my knowledge for the last twenty-five years in the hope that something practical might be developed. One of the principal impurities in feldspars is mica, a much lighter substance than feldspar, and the air separators gather up all the light weight mica with the finest grinding of feldspar, which we want for our highest grades, with the result that all the mica becomes segregated in the fine feldspar.

Another competitor, an older miller, probably knowing the futility of air separation, experimented recently with the screening process but the abrasiveness of feldspar caused his screens to wear out faster than he could put them into the machine. It is said that the experiment showed that the cost of this kind of treatment would add more than $1.00 per ton to the price of feldspar, and the miller would not be getting anything except the doubtful value of advertising a project that did not work out to practical advantage.

And now a word for the intermittent mill, the type for which it has been said "that fine grinding under these conditions is like trying to pulverize sea sand by striking the beach with a hammer." That is a very pretty simile. I regret that practical experience knocks it into a cocked hat.

The finest grinding of feldspar in this country today and for the past twenty years is required by the Orford Soap Co., makers of Bon Ami. Their specification demands a test by which 16 ounces of feldspar is stirred into a couple of gallons of water and then run over a 200 mesh brass lawn. In these 16 ounces there are 7000 grains. If the residue on the screen when dried weighs in excess of 5 grains (about $^1/_{12}$ of 1%) the material is not acceptable. I think you will admit that this is a severe test. Fineness of that kind cannot be obtained in a continuous mill. No form of air separation has yet been devised that will give it to you in quantity sufficient to make it commercially valuable. How then do we get it? Why, by "taking our hammer down to the sea shore" and grinding in an intermittent mill.

There is plenty of feldspar to be had from experienced millers, which in any kind of normal times will be carefully selected, up to the price you are willing to pay for it, and *down* to any price the miller has to take for it. Do not spend all your time reforming the miller. Take a little of the medicine yourselves, and remember that it may be well to limit your purchasing agent to feldspars that have borne the tests and the practical examination of ceramic engineers who know their business.

MR. LADOO:—Mr. J. P. Rodgers has prepared a serious indictment. I talked with Mr. Rodgers quite a while on the train, and I am convinced

that his idea of the feldspar industry and mine are not so far apart as his criticism seemed to imply. He spoke of the condition during the past few years. That is absolutely correct, and I realize that practically no effort to improve on the milling methods has been made. During the past few years, as a matter of fact, improvement has been at a standstill. That horrible example which he mentions, I believe I am right in saying, refers to one of the oldest and one of the largest feldspar grinding companies in the country. It is also true, as he says, that the grinding efficiency has been increased by drying. If the plant is run by steam, it might be much cheaper to use your waste steam to run your drier instead of the method suggested by Mr. Rogers, but if your mill is electrically driven it might be cheaper to put in some form of a rotary drier. The statement of capacity of the mill is actual and not estimated. Mr. Rodgers stated he gets 4500 pounds; that is two and one-fourth tons—is that with a drier or without?

MR. RODGERS:—That is working on the dry material, but not material that has been dried artificially.

MR. LADOO:—I believe the grinding capacity when grinding some materials can be increased by drying and the capacity of the so-called ideal material can be enhanced by use of the air separator which takes out the fine material. This would increase the capacity of the mill making it possible to get four tons through the largest type of Hardinge mill. With reference to mica, that is a proposition that must be worked out a little further before determining whether or not air separators can be used on all types of feldspar. But I cannot see how the question of mica is involved in the use of air separation, because there appears today to be but two means of getting out mica. First, the mine run may be selected to exclude all the mica the feldspar contains. The only alternative seems to be by screening. Screening, I will have to admit, has not been very successful. In fact, screens have been thrown out of feldspar mills as being unsatisfactory for the reason that the screen wears rapidly, mica gets into the openings, and the screens blind. If the mica cannot be removed by hand sorting or screening, it must stay in. If the mica stays in, I do not see that an air separator can either improve or injure the product. I do not believe that any manufacturer of air separating equipment would claim he could get out the mica. I have never seen one that could. Air separation, as used today, is a sizing, not a purifying, process. I do not think the questions of mica and air are at all connected.

MR. SMITH:—We have two mills. In one of them we use a large crusher. It is an 8 x 10 crusher. So far as our practical experience has been, I think there is almost no difference in analysis between the product of one mill and that of the other with the manganese steel jaws.

MR. LADOO:—That to me would seem absolutely correct. I cannot see how the crusher with the manganese steel jaws can add any more iron

than would be added by sledging and the various methods of handling. You would probably add just as much iron or more iron by sledging than by using the crusher. I think some standard should be obtained on that point.

There is one point which I would like to emphasize in the defense of the feldspar millers, and that is the question of price. The price of ground feldspar has not gotten back to pre-war prices and it never should unless conditions change radically. I hope it will not under present conditions because it would mean bankruptcy for many feldspar companies.

I think the parties that should be most interested in obtaining adequate supplies of uniform crude material should certainly be willing to pay a price which will give the feldspar millers a seasonable profit. The history of feldspar mining in this country and Canada shows that the industry in the early days was very crude. They took the finest feldspar closest to the railroad, discarded all the rest, threw it away on dumps, and moved on. Now they must either use the lower grade of materials near the railroads or haul the material which is located further away from the railroads. The costs must be higher if feldspar must be hauled long distances. I can see no return to the low prices prevailing before the war.

Referring back to the question of iron in the feldspar, what percentage of iron aside from specks of metallic iron should be allowed in feldspar? What amount could be tolerated in high-grade feldspar?

MR. SPURRIER:—I am afraid that is a proposition that cannot be answered. It would be out of the question to estimate that. I would not want to say how much; we should have a standard.

MR. LADOO:—I think it is very important for the purchaser and consumer; (they go hand in hand) that some form of standard should be settled upon. If the potters try to set up absolute standards, the feldspar millers might find them impossible to meet. If the millers attempt to set up standards, the potters might take issue. I think they both should get together and work out standards mutually acceptable.

Discussions Received since St. Louis Meeting

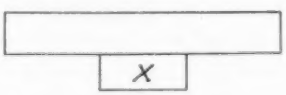
BY R. H. WAINFORD:—As our company is one of the oldest and largest feldspar concerns (capacity 1600 tons a month) it will not, we hope, be out of place if we take up the cudgels in defense of ourselves, and also of our mining and grinding friends, as we feel that the statements made by Mr. Ladoo are very sweeping and while there may be instances that give color to all of his assertions, we hope and feel that they do not apply to our industry as a whole.

This paper will, no doubt, be read by the pottery manufacturers, who urged the investigation, with as much interest as the feldspar producers

themselves, the investigated parties, as consideration of this subject has been extended away beyond our fields of endeavor and right into the very core of the ceramic industry itself of which the feldspar producers are only a minor incident.

It seems to me that the mining experts of the Bureau of Mines in this investigation have neglected the vital parts of the feldspar industry, *viz.*, the prospecting and getting of feldspar. Prospecting for and quarrying of feldspar is many times more vital to us than the grinding which is a mechanical process.

The paper refers to other industries that have gained by the adoption of scientific and automatic processes, while the ceramic industry has contented itself with old fashioned ways; engineers unacquainted with pottery plants very often make this analogy, the pottery industry, however, is totally unrelated to any others. Again let me say, I am entirely out of agreement with Mr. Ladoo on this question of out of dateness compared with the steel trades or any other and the pottery trades. There has been just as great advances in every sense that need to be applied in the industry now under the magnifier. Mr. Ladoo has shown two flow plans; the first being a grossly exaggerated case and the other ideal. They remind me of a black board sketch made at the Philadelphia meeting of this Society. The sketch looked like the one given here:



The little chap on the side was explained to be the combustion chamber, that when properly designed would end, for all time, kiln-firing troubles that have been troubling the potters for the past hundreds of years, and give money in the pocket besides. I have marked this wonderworker with the letter (x) as this is the algebraic sign many of the members have been looking for since that time.

I will now endeavour to reply to Mr. Ladoo's "outstanding features" numbered 1 to 9 on the first page of his paper. These might have been styled "charges."

(1) In regard to the statement that many grinding companies do not own or control their supply, I would say that for our Cathance, Me., mill, we have obtained feldspar from our own quarry for over 50 years. For our Trenton Mill, we obtain feldspar from a New England State, and before obtaining this quarry we investigated a score of deposits in this country and Canada, making a large number of analyses and physical tests of samples from prospectors whose deposits were for sale. So we do not buy in job lots.

(2) The engineering control of our business is unfortunately in the

inadequate hands of myself, a mechanical engineer, so titled by the British Institution of Mechanical Engineers. The quality of product control has been in efficient and trained hands. One of our mills and the deposits attached to it were superintended for about forty years by a gentleman whose name was known to all the whiteware manufacturers of the old school in this country. Unfortunately he has now passed away. He was always inquired of, with not only esteem but affection, and our product was as much known by his name as ours. Our present manager and superintendent, trained at Harvard and Massachusetts Inst. of Tech., is this gentleman's son, and was his assistant for 16 years before taking over the official duties. Our mill at Trenton and its deposits of feldspar are in the main looked after by one of the products of Prof. Brown of Rutgers. The treasurer of our company who has been connected with the manufacture of whiteware pottery all his life also interests himself in both plants. He professes to be a "practical potter" and only hopes that he gets somewhere on the outskirts of this designation; if he reaches that, he wishes me to state that he desires no better compliment.

(3) Regarding the out-of-date and obsolete inefficient methods of grinding; our mill in Maine was first operated by water and so was placed where there was a head of water. It was fortunately also at the head of tide water, where, before railroads were operated, the ground product was bagged and sent down the river in boats to its destination. Years passed along, the railroad came within a quarter of a mile of the mill and the product was then loaded on the railroad. As years passed, the forests were cut and water became more and more intermittent; then we put in a steam plant and at a later period an electric plant to keep in touch with modern witchcraftry. We, however, still run this mill by water power, when the head of water is available, which it is for about three months in the year.

Our mill at Trenton, was erected last year. We concluded after a great deal of thought to continue to use periodic cylinders and chaser mills. There may be other methods which many would think are more efficient and produce a better product, but we have produced a definite product for many years, hence our choice of machinery is not without experience or knowledge of what is the best. This plant is electrically equipped and provided with suitable apparatus to protect the health of our employees and has such devices for the manipulation of the products that seemed desirable, always bearing in mind as we had to do, that what our customers want is not how automatically we can run our mill, but the proper kind of feldspar which they use as only one of the ingredients in the manufacture of their products.

(4) We do not know what is meant by lack of coöperation among feldspar producers. They are not secretive. When Mr. Ladoo visited us

at Trenton, he was shown around our plant, which was then almost completed for working and was given a letter of introduction to our manager in Maine asking that he be shown every civility and given such information as would be useful for his report. He was invited back to Trenton to see the mill in operation which he promised to do, but did not return. Our fellow feldspar producers have been invited and some have visited our mill; a number of our customers have also done the same. From this it will be seen that we are not secretive in our methods; at the same time, we hardly see why a manufacturer must be taunted if he refuses to throw his plant open for public inspection.

(5) This is probably so.

(6) We presume that deposits of feldspar near a railroad that are continuously worked will get depleted, for what is taken out can never be replaced. If any one knows of a good deposit of feldspar near a railroad, we hope that he will not be secretive, but show a broad spirit and put us in touch with this desirable spot.

(7) We are going to leave it to our manufacturing friends to either defend themselves or excuse their shortcomings as pointed out in this paragraph.

(8) We think that more than half the capacity of grinding mills is taken up in grinding flint, cornwall stone, french flints, etc. We may be charged with wasteful over-production in building our new mill at Trenton, but in partial explanation of this we desire to state that twice our mill at Cathance, Me., burned down, and we were put out of business for long periods. We built this mill to protect ourselves against a recurrence of this fate. We can now carry greater stocks of finished material and fill orders in rush times.

(9) We regret that Mr. Ladoo has made this statement without being more explicit. Of course we do not intrude in the manufacturing operations of our friends and can only answer for ourselves, though we see no reason why they should not have some glimmering of intelligence in the preparation of their materials.

We have always had tests made for uniformity of our products and a standard of grinding. This is looked upon as being one of the fundamentals that are essential to a product like ours and which the potters who buy from us naturally expect to get.

By Harlowe Harding:—Mr. R. H. Wainford has made a very comprehensive discussion of Mr. Ladoo's article on the grinding of feldspar and there is no denying that many of his points are well taken, although I do believe that he has misunderstood the intent of some of Mr. Ladoo's recommendations.

Mr. Ladoo's reference to the adaptation of a process employed by one industry to another, in my opinion had reference to methods of grinding in the mining practice as compared with the ceramic industry, for in the treatment of ores, fine grinding plays a very important part in the whole process, and as a result, as much energy is exerted in solving this problem as in all the rest of the processes put together. It is here where the costs are usually the highest.

The mining industry has reached a stage where the saving of a few cents per ton of ore ground means a great deal, and in some cases spells the success or failure of the entire project. Literally, hundreds of methods of grinding have been tried out in this industry and only four or five systems have survived, all of which are continuous in operation. These systems involve wet grinding but the same condition holds true for fine dry grinding as has been demonstrated in many cases on record.

The present method of grinding feldspar by the intermittent process, usually with chaser mills or batch tube mills, is still profitable. No one can deny this point when we consider that in grinding in this manner the established producers are making money, for so long as this method is generally employed in the ceramic industry, those producers will continue to profit.

What Mr. Ladoo brings out is that the better known producers may be superseded by new companies who "take a chance" on installing a continuous system and are able to produce just as satisfactory a product for about half the cost. The well-established companies will not feel this competition until there are enough installations of the new system which are able to secure a satisfactory grade of feldspar and sell their product considerably below that which the older companies could afford, or unless these older companies fall in line and cut their production costs to meet the "young competitor."

There are many "ifs" to this argument, it is true, but there are enough facts which have shown a disinterested investigator like Mr. Ladoo what will come to pass.

Mr. Ladoo certainly laid himself open to attack when he recommended changing the milling system to such a radical degree, but it stands to reason that unless he had had ample proof that such changes had effected the economies claimed, he would never have dared present such radical recommendations.

It was intimated that Mr. Ladoo showed partiality to a particular system and advocated certain types of apparatus. Why shouldn't he if by so doing a benefit to the producer would result? The benefit derived by the manufacturers of the machinery involved in this plan is negligible compared with that accruing to the producer through years of operation.

By R. F. Segsworth:—Mr. Ladoo's paper on conditions in the feldspar industry impressed me both by the soundness of the theories set out and by the fact that the findings given as to conditions in the industry correspond closely with the results of our own prior investigations. Mr. Wainford's reply thereto has left the above impression unaltered.

We leave to Mr. Ladoo the replying to the criticism of the general scope of his inquiry, the form of his report, the question of whether or not his suggestions have been only destructive and not constructive, and the possibility of submitting further evidence in support of his assertions. Suffice it to say in passing that the improvements suggested do not appear to be in use by all companies, and that thirty-five or more years' experience is no answer to Mr. Ladoo's criticisms.

The discussion naturally falls under two heads: (A) Mills and consumers. (B) Mines and producers.

(A) With the first of these, we, in Canada, are but little concerned, owing to the almost entire absence of any grinding mills. At present there is in operation only one small mill. In view of the immense quantities and high grade of feldspar still to be mined in Ontario, the question of establishing mills in Ontario should be of interest to American grinders and consumers. The following figures show the production of crude feldspar in Canada, and in reading these it should be remembered that the Richardson mine at Verona, Ont., one of the largest producers of high grade feldspar on the American continent, has been shut down for the past four years, but is being re-opened within the next three months.

Feldspar Sold (Tons)

1911	1912	1913	1914	1915	1916	1917	1918	1919	1920
17724	13733	15935	18060	15455	19488	19462	18782	15955	32000

Up to the present, Canada has exported practically all its crude feldspar to the United States and imported from them nearly all its annual consumption of ground feldspar. At least 95% of the production of Canadian feldspar has come from the County of Frontenac in Ontario and the County of Ottawa in Quebec, and 90% of the total Canadian production has come from the Verona district in the County of Frontenac, near Kingston, Ontario. Recently deposits in the Buckingham district in the County of Labelle, Quebec have been opened which indicate the presence of a considerable quantity of feldspar of good quality. In 1900 the Verona district produced 4000 tons; in 1920 it produced 32000 tons. With improved transportation facilities, and the consequent reopening of the largest quarry in the district, the next year should see this production practically doubled—a field well worthy of the consideration of the American grinders and consumers.

(B) Mines and Producers. The conclusion to which Mr. Ladoo comes

in this connection is that the great need of the industry at present is a continuous production of high grade feldspar of a uniform quality. To this, Mr. Wainford's only answer is a challenge: "If any gentleman knows of a good deposit of feldspar near a railroad, we hope he will not be secretive, but show a broad spirit and put us in touch with this desirable spot." This challenge we accept.

(1) Quantity. We have referred already to the quantity of feldspar available in the Verona district. Perhaps it should be added that competent engineers have estimated that the Richardson quarry contains at least 300,000 tons of high grade feldspar; the same authorities believe that much greater tonnage is possible but this tonnage they consider certain. Anticipating the improvements now being made in transportation facilities, some 4000 tons of feldspar of a uniform grade are now ready for shipment.

(2) Transportation. There are a number of properties in this district only a few of which have been operated. None of them have been on a railroad and this has held back greatly their development, as the bush road has been possible only during a few months of the year. However, this drawback is now being completely removed as a means of transportation will be completed as soon as the frost is out of the ground, whereby shipments can be made at all seasons of the year. With the completion this spring of these works, it is expected that all quarries in the district will be operating at full capacity.

(3) Quality. The analysis given in the Bulletins on Feldspar and records at Washington, London, Ottawa and Toronto earmark the feldspars in the Verona district, Ontario, as being of high grade and in spite of the disadvantage of lack of transportation facilities they have always been able to get and keep a fair share of the high grade demand in the United States.

Bulletin No. 420 by Edson S. Bastin, issued by the United States Geological Survey is the most authoritative and comprehensive treatise on the feldspar situation in the United States. Under Grade and Prices, page 21, Bastin says: "Most dealers recognize three grades of commercial feldspar: No. 1, No. 2 (sometimes called Standard), and No. 3. No. 1 is carefully selected, free from iron bearing minerals, largely free from muscovite and contains little or no quartz, usually less than 5%. Analysis 6 of the table on page 9 shows the character of material of this grade. On the same page Bastin gives a list of prices for crude and ground feldspar—crude Canadian feldspar is quoted at $0.50 a ton higher and the ground Canadian feldspar at $1.00 per ton higher than any other grade. In all publications on feldspar the Canadian feldspars are given as examples of typical high grade, hard, potash feldspars.

BY H. SPURRIER:—In considering the question of feldspar it is obvious that the rock should be suitably free from objectionable minerals such as excess silica, mica, garnet, etc. This being the case, the question resolves itself into what happens to the feldspar during (1) grinding and milling; (2) transportation; (3) its sojourn in the potter's bins; (4) its being made into slip.

During all these experiences the feldspar is exposed to liability of contamination with free metallic iron or iron oxide. Contamination with free metallic iron or iron oxide is far more objectionable than an equal amount of iron existing in a more complex state of combination.

The following data relative to the amount of free and combined iron in potter's materials may be of interest.

The total iron content of a well-known ground feldspar showed on analyses, made ten months apart, 0.53% and 0.50% calculated as Fe_2O_3 and nine months later 0.45% Fe_2O_3.

The same feldspar showed on a careful magnetic separation 0.0016% metallic iron. A widely used domestic kaolin showed on two analyses made eleven months apart 0.80% and 0.68% of iron oxide. A careful magnet separation showed metallic iron 0.0004%.

Two samples of the finest white Canadian orthoclase feldspar showed 0.26 and 0.18% Fe_2O_3. These specimens were of extraordinary clearness, a fine hand specimen of two inches thickness being distinctly translucent. In preparing these samples for analysis they did not come in contact with iron at any time.

The following survey of the metallic iron content of raw materials, and dust made for dust-press practice from these materials may be of interest.

Feldspar taken from bin gave metallic iron 0.0016%. Flint taken from bin gave metallic iron not weighable. Standard mix made in porcelain mill and not coming in contact with any iron—0.00036%. Commercial slip coming from blunger before reaching electro-magnets—0.00129%. Dust from dust house—0.00193%.

An examination of dust collected in the immediate neighborhood of a crusher used in preparing dust showed an iron content of 0.011%. The iron content in this dust was not of the minutely fine character formerly noted, but appeared to suggest hack saw dust.

While the above facts may not be entirely pertinent to a discussion on feldspar, they are nevertheless, not entirely irrelevant, and would seem to indicate that potters need to "clean house."

As far as my own experience goes it seems that the crux of the situation lies in the selection of the proper grade of feldspar before crushing and grinding, as there seems little to fear from grinding and milling as practiced by reputable millers. Surely potters have no complaint to make of a feldspar that shows 0.0016% of metallic iron and this iron of a great degree of fineness.

By N. B. Davis:—Perhaps Mr. Ladoo has been carried beyond practical bounds in his endeavor to describe the conditions in the U. S. Feldspar Industry, but he has, nevertheless, succeeded in stirring up considerable interest that should eventually mark a period of advance.

During the past two years 3 or 4 new plants for grinding feldspar have been built in the United States using continuous and intermittent types of grinding equipment. There are two different systems of continuous mills—one using screen separation, and the other air separation, in sizing the final product.

It would be of considerable benefit to the industry as a whole if a study of results obtained could be undertaken and the data presented to the Society.

It is difficult to understand why advances should not be made in the milling of feldspar when all other industries turning out fine products have recorded improvements.

It is true that in general the milling costs of feldspar are too high, mainly because of the limited grinding capacity of the individual mills.

The problem of grading feldspar appears to have received the least attention in the original paper or in the subsequent discussions. From the standpoint of straight feldspar there are no commercially pure potash or soda silicates, but there are innumerable mixtures of the two, due to natural intergrowths and the material on the market shows this considerable variation. Products that are not feldspars but mixtures of quartz and feldspar with the latter predominating, are referred to by some producers as No. 1, while other producers rightly term feldspars without impurities, No. 1.

Would it not be better to have standards arranged for various products, and in this way aid the potter in looking for his sources of supply?

I am sure the Canadian producers are not at all secretive, and are only too glad tc have visitors call on them. Speaking for our own interests, I might say that we would be very glad to have anyone interested spend a day with us at our quarries.

Prior to 1921 a number of grinders operating their own quarries shipped material that they would not accept from outside producers, and as a consequence, when the call came for a greater production, particularly during 1920, the whole grade of the output was lowered. Then came the complaints of the potters.

Mr. Ladoo was quite right in saying that eventually the quality of the material supplied would depend on the price allowed by the potters, so that in reality the ultimate consumer controls the quality.

By Edward Schramm:—Mr. Ladoo's very interesting paper deals primarily with feldspar milling problems. It may not be out of place to

present a few observations on feldspar from the point of view of the manufacturer of vitreous ware who is interested chiefly in quality.

The chemical requirements are high potash, low lime, low iron, and constancy of composition. A product high in free silica produced by the grinding of pegmatites or "graphic granite" like the Maine product is satisfactory, provided iron bearing impurities are low. However, the percentage of free silica in a feldspar of this type is likely to vary from time to time. Ordinarily these variations are not serious in a body composition, but for use in the glaze it has been found desirable to make a careful analysis and to adjust the feldspar contents so as to hold the SiO_2 proportion constant. Analyses are not required frequently if a carload shipment is set aside for use in the glaze only.

The determination of alkalis is frequently regarded as a stumbling block in the analysis of feldspar. However, with a little practice this determination can be made with great accuracy. Two critical points are the fusion and the separation of potash and soda. In the former, as shown by Hillebrand, the crucible should be heated to a high temperature after the initial slow heating to insure complete decomposition. The separation of potash and soda as perchlorates is very accurate if we use 97–98% alcohol which can be prepared by distillation of the 95% product over lime.

The production of a high grade feldspar depends on the success of the prospector in locating workable deposits with a high percentage of practically pure rock. We know of no commercially satisfactory method of eliminating such impurities as biotite, tourmaline, garnet, pyrite, hornblende, and surface iron, which introduce dark specks and impair the color of the fused feldspar. With regard to iron introduced in milling, we confess to being among those with a prejudice against jaw crushers because of the rubbing tendency in these machines. Chemical analysis of the product is not a sufficiently sensitive means of detecting this contamination. A few specks of iron sufficient to ruin the appearance of a fine china body, would hardly be found by the analyst. The only valid test is the comparative appearance of the buttons fired under identical conditions.

The fire test is conveniently made by placing a 50-gram sample in a heavy biscuit egg cup covered by a small butter plate and firing in the biscuit kiln. The purpose of this test is to judge cleanness and color. The degree of fusion of the button is not to be relied upon as an indication of fluxing power of the feldspar owing to the action of quartz in lowering the fusion point and to the increase in fusion point with increasing proportion of potash.

The fineness of grinding is a matter of great importance. The common use of metal testing screens of from 150 to 200 mesh gives little information to the consumer since such screens are not of the right order of fineness. The ideal test would be by elutriation or an analogous method, but this

scarcely appears feasible for routine work. The use of finer sieves gives a fair measure of the degree of coarseness. We use for the purpose either a XX16 silk lawn or a 250 mesh metal screen. The rejection on the 250 mesh metal multiplied by 1.4 will come very near the rejection on the XX16 silk. The particular standard rejection demanded will, of course, vary greatly with differences in manufacturing conditions. Silk lawns show considerable variations and the use of the metal screen is, therefore, preferable, even though the metal screens finer than 200 mesh are not guaranteed by the manufacturers as to uniformity of opening. In any case the material should be washed through the screen in slip form. The dry test is apt to mislead especially if the material is in a damp condition. This is particularly true of feldspar which has a greater tendency to matt than other materials.

By R. C. Purdy:—Mr. Ladoo described tests which millers of feldspar and the users of feldspar should make to obtain information regarding quality variation in constitution and accidental impurities. These have been touched upon by others in the discussions. I will here discuss only the chemical test.

A feldspar deposit that is worth working for A–1 feldspar can be quarried with a profitable output of clean mixture of feldspar and quartz, the feldspar portion of which will run constant in composition over quite a large portion of the quarry and a considerable period of time of milling. Records of shipments for month after month from three different quarries have shown that the composition of the feldspar portion of the material remained constant. The only variation was in the proportion of feldspar to quartz.

This having proven to be the case it was plain that it was not necessary to analyze the shipments for any thing other than SiO_2. Having determined by the hydrofluoric-sulphuric acid treatment the total SiO_2 in the sample, it is clear that the remainder consisted of the RO and Al_2O_3 of the feldspar. The SiO_2 belonging to this amount of RO and Al_2O_3 being known, it is readily figured, and this subtracted from the total SiO_2 gives the amount of quartz in the sample.

It is advisable for both the miller and the user to make complete analysis of the feldspar at stated intervals or whenever there is suspicion that the character of the feldspar mineral in the sample has changed. In my experience such a complete analysis was not necessary more than once in six months at the most and generally not more often than once in a year.

There is little to be learned from the difficult determination of the alkalis and alumina which is not disclosed by the easily accomplished and sufficiently accurate hydrofluoric determination of the total silica. For a routine test this determination is recommended because of its speed

and its closer approximation to accuracy than the determination of the alkalis or alumina by most of the routine chemists.

This simple test in connection with a petrographic determination will give more real information than will a total ultimate analysis, and the conclusions will be based on actual observations, there being no need for assumptions such as must be made when the mineral constitution of the sample is figured from the ultimate analysis.

By H. Spurrier:—Recently Mr. Schramm of the Onondaga Pottery asked me how I determined very small quantities of metallic iron in clays, feldspar, etc. After reading the method used he suggested that I forward it as a contribution to the discussion on feldspar.

Two and a half kilos of the material (feldspar, clay or flint), are well stirred up with water in a large tin lined or white enameled pan having wide flaring sides, as much like a miner's pan as possible.

Any lumps should be broken up and thorough admixture ensured, allowed to settle a few moments, and then any supernatant liquid together with a little of the solid material is poured off. This is repeated till the bulk of the solids has been reduced to about five hundred grams.

The procedure from now on is precisely that of the miner in "panning" gold. The contents of the pan are diluted with water, the pan being held at such an inclination over a sink that the water just comes to the edge. By an elliptical and gyratory motion the contents of the pan may be kept in agitation allowing heavy materials to find the lower levels, thus making it easy to allow only the lighter portions to be poured portionwise over the edge without any danger of losing heavy material. When a little dexterity has been acquired in doing this, it can be done very rapidly and with great precision. During the last part of this separation it is well to use distilled water.

The final bulk of the solids and water may be reduced to about 100 cc., which are washed into an evaporating dish, allowed to settle thoroughly, the settling taking place quite rapidly. All the supernatent liquid that can be safely poured off with the aid of a glass rod held at the lip of the vessel should be removed, using considerable care.

The residue should now be thoroughly dried and the dried mass carefully powdered. One pole of a powerful magnet, is now provided with a sheath of thin paper, which being thus protected is used to pick up the magnetic particles. On slipping the magnet out of the sheath held over a sheet of glazed paper the attached material, of course, falls off. This procedure should be repeated till examination with a good lens shows nothing but iron and the usually attendant particles of magnetic oxide.

The material may now be weighed on a chemical balance to the nearest

milligram, each milligram representing 0.00004%. It is as well at first to make a trial by adding a known quantity of fine iron filings to a definite quantity of clay and panning it. This will take care of the personal equation, which however will change as skill is acquired, and establish confidence in the result.

By C. C. Treischel:—Mr. Ladoo has provoked a discussion that can not help but benefit both producers and consumers if each will accept their share in the responsibility for the deplorable condition of our feldspar industry for the past few years. The producers' part has been pointed out. The consumers' share is their neglect in providing the producers and themselves with standard tests and specifications covering the different grades of feldspar used in the several branches of the White Wares industry.

The need of such specifications can not be denied. If prepared, they would assist greatly in the reorganization of the producing end of the industry. They would indicate to the producers just what was demanded by the White Wares manufacturers as to quality and uniformity. Standard tests would form a satisfactory law covering controversies over quality, etc. The matter of purchase of feldspar would then be on a sound basis and both buyer and seller would know where they stood.

I suggest that the Committee on Standards prepare suitable physical and chemical tests for feldspar. Further, I suggest that the Research Committee of the White Wares Division prepare purchasing specifications covering the various grades of feldspar used in our industries.

By Charles M. Franzheim:—This is unquestionably one of the best papers I have ever read pertaining to this industry. It is very comprehensive, complete and true to conditions, and I have read it with a great deal of interest and care from a critical standpoint.

How Mr. Ladoo hit the nail so squarely on the head, not being actually in the industry, is a revelation as so very few people in the industry, that is the old people, really get the right angle on the situation and he certainly has done so and is to be commended.

Hardinge mills, to our knowledge, have proven fine where only 100 mesh or less is required, but they have not proven a success, to us at least, where grinding feldspar 130 mesh or finer is required.

Our engineers in Maine, as well as ourselves, have visited all of the high class engineers in the country, sought all kinds of expert engineer's advice for better grinding methods, but so far we have not succeeded in changing our plan, without materially increasing cost. The principal reason for all this is because of the peculiarity of the feldspar rock itself.

However, we wish to congratulate Mr. Ladoo on this feldspar masterpiece. It is the best thing we have read, and hope it will be brought forcefully before the Society.

General Replies

By R. B. Ladoo:—Several discussions of my report on feldspar have indicated that the purpose of the report was not fully understood. When the Bureau of Mines was requested late in 1920, to investigate the feldspar industry the problem presented was: "What are the reasons for the continued shipment of poor and un-uniform grades of feldspar during the past few years and what assurance have the ceramic industries that grades in the future may be improved?" The situation seemed so serious that the Bureau felt that the investigation was justified, realizing, however, that the purpose and results of the work might be misinterpreted by a few people. The purpose of the inquiry, therefore, was to find and list the troubles of the feldspar industry which were directly or indirectly responsible for the shipment of poor feldspar. The point was not to report on all phases of the industry but merely upon the unfavorable aspects. During the course of the investigation much additional material was gathered which will be used in a later report on all phases of the feldspar industry but such additional information was not included in the report under discussion as it was not considered pertinent.

The investigation progressed during the whole of the year 1921. Visits were made to mines and mills and to undeveloped deposits, conferences were held with producers, consumers, consulting engineers and chemists both in this country and in Canada. All collateral information was obtained so as to enable the preparation of an unbiased report representing all phases and interests in the industry. After the report was prepared in a preliminary way copies were submitted to engineers, chemists, ceramists, producers and consumers for criticism, correction and amendment, and the criticisms so received were incorporated in the final report. Therefore, the report as issued represented not the author's hasty judgment but the well-considered opinions and experience of a large number of people representing all phases of the industry.

It was inevitable that the report should be misunderstood by a few people and that they should look upon it as a hasty and unwarranted attack upon the whole feldspar industry in general and upon their own operations in particular. This was anticipated but it was believed unavoidable. The Bureau believed that most producers and consumers would find in the report an impartial and disinterested exposition of the unfavorable conditions as found and that the criticisms would not be accepted where they did not apply. The only alternative to the issuing of the report as it stood

was to write a report which presented the good points and glossed over the weak points. Such a report might have been found more acceptable to a few but it would have been of no value technically and the work would have been wasted.

All of the conditions enumerated in the report were actually found in practice although of course they were not all found in any one plant and some applied to but a few plants.

Some objection has been found to the use of the names of specific machines in the flow sheets presented. It should be understood that the "suggested flow sheet of improved mill" is a composite flow sheet containing methods and machines found by experience to be the most efficient in actual feldspar grinding practice. Thus it is not a theoretical flow sheet but a composite flow sheet of methods and equipment from actual mills. Furthermore, it is not suggested that this flow sheet may be taken as an ideal flow sheet for the grinding of any particular type of feldspar. It is merely offered as a suggestion or as a basis for experiment toward the improvement of present methods. It is fully realized that some of the machines suggested can not be used successfully in the grinding of certain feldspars, but it is true that these machines have been successful in actual use in the actual grinding of other types of feldspars. Furthermore, it should be remembered that improvements in grinding and separating machinery are constantly being made and the fact that a machine was tried out some years ago and found unsuitable is not sufficient proof that the most modern type of this machine would not be successful.

It is true that the unsatisfactory conditions which prevailed in 1919 and 1920 were in part due to labor conditions and to unusually large demand. However, the dissatisfaction with some of the types of feldspar shipped began prior to 1919, and the causes of such unsatisfactory material were accentuated by the unusual conditions. Since the beginning of the industrial depression, late in 1920, feldspar producers have had an opportunity to select their feldspar more carefully, to weed out inefficient labor and to make repairs and improvements in their mills. Thus the feldspar shipped so far during 1922 has been of a better grade and it seems probable that many changes and improvements will continue to be made in the methods of mining and milling.

Engineering and chemical control, to a certain extent, is now being practiced by some of the feldspar producers. This control is more easily effected when the feldspar grinder mills only feldspar from deposits which he owns and operates himself and where such deposits are large and fairly uniform. The greatest difficulties arise when feldspar is purchased in small quantities from a great many different deposits not owned by the feldspar millers and assembled at one mill. At such mills blends must be made and it is very difficult to control the composition of the blend by present methods.

There seems to be some difference of opinion as to the most efficient method of fine grinding. In many of the non-metallic mineral industries, in which fine grinding is necessary, grinding was formerly done in pebble mills of the intermittent type but they have been largely superseded, except for batch grinding, by continuous processes. Thus in the grinding of barite, talc, whiting, etc., very fine grinding is now being done successfully in continuous mills either dry, using an air separator, or wet, using some form of classifier. The specifications for some of these products are very exacting and require material that will pass a 300 mesh screen. Since feldspar need be ground only to pass 140 mesh screen, or at the finest a 200 mesh screen, the possible increase in efficiency by the use of continuous grinding methods should at least not be overlooked.

BY R. B. LADOO (to R. H. Wainford):—It is with some hesitation that I attempt to reply to the discussion by Mr. Wainford for I believe that Mr. Wainford has not fully understood the purpose of the investigation and the meaning of the report. Furthermore some of this discussion is of such a nature as not to need reply. However, I will reply to a few of the technical points made in his discussion.

The nature of the investigation and the type of report desired precluded the possibility of going into details as to possible improvements in methods of mining and milling. The object of the report was to give as concisely as possible the reasons for the production of poor feldspar and a summary of some of the possible remedies. A detailed discussion of all phases of the industry was purposely left to another and more lengthy report which will be issued by the Bureau at some time in the future.

My references to improved methods in other industries were not based upon the iron and steel industries but upon other nonmetallic mineral industries which have passed through the same stage through which the feldspar industry is passing, for instance the cement industry and the lime industry.

The use of flow sheets in describing milling operations is so well established and is so well known that the use in my report seems to require no defense. As for the methods suggested, a careful reading of the report would reveal the fact that the suggested flow sheet was a combination of machines most successfully used in various plants visited. In other words it is a composite flow sheet of the best features of a number of plants. The use of these machines is not advocated for any plants but it was thought that this composite mill might offer suggestions for experimentation in the improvement of present practice.

The points covered in Mr. Wainford's numbered paragraphs one to nine are replied to in part in my general discussion. It is unfortunate that

Mr. Wainford considered my remarks only in their application to his own operations. It has been repeatedly pointed out that the faults enumerated in my report were but an enumeration of all of the faults found in all of the plants and that they do not all apply to any one plant, but, on the contrary, there are some plants to which but one or two of the faults would be ascribed. However, there is definite and ample proof that all of the faults enumerated may be actually found distributed over the whole industry.

In regard to secrecy of operations it is true that Mr. Wainford extended every courtesy to me while at his plants and I greatly appreciated the coöperation shown. It is also well known, probably to Mr. Wainford as well as other feldspar producers and consumers, that there are companies which are very secretive and which do not allow examinations of their plants and which will divulge no information either to competitors or disinterested parties. Fortunately this applies to but a very few companies.

The feldspar producing capacity of the country was very carefully computed not only from records of actual production but from statements by producers checked by a calculation of actual mill capacities. These estimates do not include flint milling capacity. This estimate clearly showed that there is an excess feldspar milling capacity in the country, a greater excess in fact than some feldspar millers realize or will admit.

By. R. B. Ladoo (reply to Mr. Purdy):—Mr. Purdy's suggested short method of analysis for feldspar can only be applied when the type of feldspar being ground does not change and the only variable constituent is the free silica. It is true that some deposits of feldspar are sufficiently uniform in character so that this method may be applied, but unfortunately there are many deposits which contain extremely variable mixtures of potash and soda feldspars together with free quartz and other deposits which nominally seem to contain only potash feldspar but in which the potash is replaced in variable proportions by soda. Furthermore, most feldspar grinding mills grind material from two or more quarries. Sometimes as many as four or five different feldspars, some of which vary in composition, are mixed and ground together to form a blend. In all of the cases just mentioned a simple silica determination would be of no value, since the ratio of silica to alkali differs in microcline, albite and anorthite.

Unless a feldspar consumer is positive that the feldspar which he is using all comes from one deposit and that the type of feldspar is unusually uniform in this deposit, it would be unsafe and very misleading to depend on a simple silica determination instead of a complete analysis. Since it is not always the practice among feldspar producers to have complete

analyses made of their different feldspars at frequent and regular intervals the potter has no assurance that the type of feldspar which he is using does not change between shipments. If fluctuations in silica content and if the ratio between potash and soda are not seriously objectionable to a potter my objection just stated is of course over-ruled; but one of the greatest objections which I have heard stated by potters to the feldspars which they have received in the past few years has been that it was extremely variable in composition and that this lack of uniformity had occasioned great losses.

The complete analysis of a feldspar is of course a slow and tedious operation but after a thorough study of the subject of analysis and after consultation with ceramists and experienced mineral analysts I have been forced to the conclusion that there are no short cuts which, under ordinary circumstances, can be safely made.

COÖPERATIVE RESEARCH ON SAGGER MIXTURES AND MANUFACTURE[1]

By C. C. Treischel

One of the fundamental reasons for the formation of Industrial Divisions within the American Ceramic Society was the promotion of coöperative research. You have read of the results obtained by the Enamel Division in their investigation of "fishscaling." You have heard of the work which is now being carried on by the Heavy Clay Products Division in their researches on firing problems. The Refractories Division has been engaged in coöperative work for a long time. Other Divisions are falling in line. Is not the time opportune for the groups associated in the White Wares Division to attack some fundamental problems which need to be solved? Does not the spirit of this period, the cry for reducing waste in manufacture, demand some combined effort on our part to strike at the heart of some of the phantoms which have dogged our industry ever since its inception during the middle ages, phantoms which we have all individually attempted to blot out, with at the best, but poor success? I believe that the time and the demand are here and for this reason desire to present for your consideration a research proposition covering one item in our manufacturing expense, an item which in losses is annually costing our industry millions of dollars. This item is "saggers" and our problem is "How can we produce better and longer lived saggers?"

During the past year my work as Secretary of your Division has been chiefly concerned with organization but I have also devoted considerable time considering various problems that have been suggested to me for

[1] White Wares Division, St. Louis Meeting, Feb., 1922.

coöperative research. Among these were raw materials, drying, firing, saggers, glazes, processes, equipment, etc., but the sagger investigation seemed to best suit our demands, *viz.*, a problem of vital interest to *all* of the groups associated in our Division; for only with a vital problem of interest to all the groups could we hope to obtain the coöperation and the financial assistance necessary to carry the researches through to a definite end.

The suggested sagger experiment printed in your programs indicates my personal views of the manner in which a research of this sort should be conducted and some of the points that should be covered. Changes will no doubt be made by those in charge of the work but I believe that these changes will involve additions rather than subtractions.

TABLE I

SAGGER EXPERIMENT SUGGESTED BY C. C. TREISCHEL FOR COÖPERATIVE RESEARCH PROBLEMS FOR THE UNITED STATES POTTERS' ASSOCIATION

LABORATORY

1. Water of plasticity.
2. Drying shrinkage.
3. Firing shrinkage.
4. Compressive strength.
5. Deformation under load.
6. Fusion temperature.
7. Vitrification temperature.
8. Cross breaking strength.
9. Fineness.
10. Experimental mixtures.
11. Effect of rate of drying on strength.

FACTORY

Methods of Preparation

1. Ground clay *vs.* unground clay.
2. Wet grog *vs.* dry grog.
3. Wet pan *vs.* soak pit.
4. Vertical pug-mill *vs.* horizontal pug-mill.
5. Re-pugging.
6. Ageing of body mixture.
7. Short period tempering *vs.* long period for wet pan.

Method of Forming

1. Power press.
2. Hydraulic press.
3. Hand made.
4. Cast.

Firing

1. Loaded and to temperature of ware.
2. Empty to temperature of ware.
3. Empty to above temperature of ware.

I believe that this investigation can be carried through at an expense of $50,000. A fairly accurate estimate which I made last summer showed that we have available in this country the equivalent of 3,000 round potter's kilns in which saggers are used. This includes those manufacturers making art pottery as well as those of our own White Wares industry. From data published in our *Journal* and from personal correspondence I estimate that our annual sagger cost is $20,000,000. If we through coöperative effort could double the life of our saggers, we would save our industry about $10,000,000 per year. If this saving could be made through an expenditure of $50,000 would not the expense be justified?

As a method of raising funds necessary to carry on this work, I would suggest an assessment of twenty or thirty dollars per unit kiln for each manufacturer. By unit kiln, I mean a standard size, say $16^1/_2$-foot diameter. If a potter uses 14-foot kilns then use the ratio 14 to $16^1/_2$ in estimating his assessment.

The foregoing, I believe covers the essentials which should be considered.

Discussion

MR. SEBRING:—It seems to me that the experiment should be done by industrial groups. I don't pretend to know the technical end of the business, but I do know something about the cost of saggers in our industry, and it seems to me that our requirements of a sagger would be much different from the requirements of the manufacturers who fire at a higher degree of heat. The highest temperature we reach is about 8 cone. I am wholly in sympathy with the idea of having coöperative research made in order to determine some way of reducing the cost of saggars. The cost at our factory last year was $3300 per kiln. I make an estimate that the cost on your white ware factories would run about $2500 per kiln. It seems to me that if the general wares were treated as a group, the electrical porcelain as another group, and so on, you would be able to get some place. I am perfectly willing to pledge now the support of our factories to any amount that is required in order to carry on that work, provided it is carried on by groups. If we try to mix up the experimental work of the electrical porcelain along with the crockery, dish manufacturers, they would not get any place. I would like to go on record as pledging my support, however, to the project as suggested by you with my added suggestion.

MR. HUNT:—I agree with Mr. Sebring that the requirements for the general wares group are not the same as for the requirements of the porcelain and like industries, but I think the project can be carried out and progress made. I disagree with him in part. I am of the opinion we would get along all right if we started out on the same basis in our experiment with

the others, but the final results should be carried on by the groups. I think the entire thing should be under a central head, but separate work in each industry.

MR. TREISCHEL:—If this thing were started, I think we would be surprised to find how similar the sagger problems for the various groups in the White Wares Division really are. Considering the basis of our industries as a whole, you will first find, in research, that we will have to deal with fundamentals. It is quite possible that after the fundamentals are established the research will perhaps have to be carried out on a basis of maturing temperature rather than industries. There are a lot of general ware people who are biscuiting as high as the electrical porcelain.

MR. SEBRING:—I do not have the exact figures, but I think there are about 600 kilns in the United States devoted to the making of general ware, and 500 in the making of other ware. All of those 500 fire their biscuit to approximately the same temperature, and it seems to me that if those are treated as one group, you would have something concrete to offer to the members of the United States Potters' Association, and I believe it can be put over. I frankly believe that it would be money well spent if we gave as high as $50 or even $100 a kiln a year for two years, or for as long as it is necessary in order to get somewhere. An assessment of $100 a kiln would mean about a thousand dollars to a factory—approximately $700,000 during a year, yet the cost to each would be very small. That would mean a thousand dollars in order to try and cut down an expenditure of approximately twenty-five to thirty thousand dollars a year—say $100 a kiln as a maximum wouldn't overburden the general ware manufacturers, but in your estimate you say there are 3,000 kilns and cost approximately twenty million dollars a year—that is approximately $6,000 per year per kiln. I am sure that is not the cost of the general ware manufacturers. I do not believe it will run to more than twenty-five hundred to three thousand dollars. But I believe that if you have a definite proposition you would get some place. It is a big problem—it is a problem that we have all tried to solve, even to the extent of using carborundum.

MR. SPROAT:—I think there should be a committee appointed to carry the work on; to investigate the different conditions representing all the White Wares groups.

MR. GOODWIN:—Would not this come under the scope of the work being done by the United Potters' Association Research Committee?

MR. TREISCHEL:—I do not know. I had hoped to get a chance to go over this matter before this came up. I think the chairman of the different research committees should get together. That is the only way the proposition can be given proper attention and representation. Or the representatives of the groups should get together. The thing that the officers of the Division would like to have is a recommendation,

showing the desirability or undesirability of this coöperative research problem. If you don't want it, we won't go ahead. If you do want it we will try it within another year. If anyone wants to put it in the form of a motion, we can put it in the record as a sort of vote of confidence.

MR. SEBRING:—I will be glad to make that motion. I think it is a move in the right direction. I have given my views, and I should like to make the motion—that it is the sense of this meeting that the manufacturers be solicited.

MR. STAUDT:—I think all the manufacturers are interested in getting closer. I said yesterday during the last twelve years I have been trying to find out how to make saggers and I have not gotten anywhere. Now is the time for us to start something.

MR. GOODWIN:—Would it not be wise to ascertain what is being done in New Jersey?

MR. STAUDT:—We have only done just as much as you have—we have been talking about it—that is as far as we have gotten.

MR. SEBRING:—A Research Committee shall be appointed from this Division. I move then, Mr. Chairman that it be the sense of this meeting that we support a recommendation that there be a coöperative movement between this Division and the various manufacturers who are members of this Association for the purpose of trying to solve the sagger problem. The question as to assessment or financing is a detail that can be handled by whoever handles the proposition.

The Secretary:—You have heard the motion, and it has been seconded.

MR. STAUDT:—I second it once more.

MR. TREISCHEL:—You have heard the motion all in favor say "Aye."

The "Ayes" have it and it is carried.

Discussions since St. Louis Meeting

BY MR. A. V. BLEININGER:—I am heartily in favor of a comprehensive study of the subject but I do not think we are ready to proceed at once with actual laboratory and plant studies. In my opinion we should first submit a brief covering our present knowledge of the subject and embodying a critical discussion of previous work. It is not at all unlikely that we already possess important information which will furnish the key to the situation and will greatly reduce the magnitude and expense of the work. It is suggested that either a sub-committee or some individual be delegated to prepare such a report. The outline suggested of work to be done is of too general a nature and we are quite apt to overlook important facts in the mass of testing data accumulated. One of the outstanding needs however is the study of the properties of the commercial sagger clays without reference to specific or special tests. It would be of great service to de-

termine the water content, drying shrinkage, by volume, the burning shrinkage and porosity at different temperatures. This study should not be expensive and would enable us to obtain a clearer idea as to what the sagger clays really are. It is generally realized that such information is not available at the present time. Special studies could then follow this work.

My recommendation therefore is: First, that a survey of the present situation on saggers be made, and, second, that the first laboratory work contemplated be the usual determinations of the properties of sagger clays. It is not unlikely that such work could be done by one of the Federal Bureaus. One of the essential tests I have failed to mention would be the strength of sagger clays admixed with 50 per cent of a standard grog, both in the dry and in the fired state, without reference to the resistance of the materials to load conditions at furnace temperatures.

By Herbert Goodwin:—This subject is one, as we all realize, that calls for study and research which we hope will be taken in hand by the research committee of the organizations interested, yet it would seem to me that a few practical suggestions would be helpful in solving this very vital problem.

Without a doubt, the mixture of sagger clay bodies and the making of a sagger are equally as important as the making of the ware which is to be fired therein, and yet up to this time so little progress has been made in this direction, due in a large measure to the fact that in the building of the potteries, the Sagger Department has been one to receive the least consideration; often cramped in some small quarters so that it could be considered a sagger shop and at other times so imperfectly equipped as to be of no use for the purpose intended. To make a perfect sagger is undoubtedly a problem very difficult to solve, but the first step in this direction after determining the best clays to be used for the purpose would be to weather; secondly, after doing so to wheel them into a drying room where the different clays could be accurately weighed and mixed in their proper proportions with the grog. The latter would have to be determined in a large measure by the use of the different clays. Some clays would permit of some fire clay, others with fine grog, others with the fine grog eliminated, and grog of one eighth mesh. There is only one way to solve this problem and that is by the aid of the Research Committee.

To state at this time the clays which have proven most satisfactory in my experience would be unwise, as it would be better to leave these to the investigations which we hope will be made. As stated by Mr. Hunt saggers which could be used with good results in a semi-porcelain factory would not be so successful in the manufacture of Vitreous China or Tile, as the sagger which is bedded with sand with the ware must have allowances made for the expansion and contraction in cooling which is not necessary with semi-porcelain ware. The study is a very interesting and deep one.

DISCUSSION ON "THE ADAPTABILITY OF THE GAS-FIRED KILN FOR THE BURNING OF CLAY PRODUCTS"[1]

By R. H. MINTON:—Mr. Richardson has clearly stated the comparison of the compartment type of kiln as compared with the old periodic type of kiln and the modern railroad tunnel kiln. The strong claim of the promoters of the railroad tunnel type of kiln has been the great saving of fuel as compared with the periodic type of kiln. This saving is accomplished through the ware in the kiln being subjected to direct firing for a short period of time only, due to preheating the ware to a fairly high temperature by the off-going products of combustion, and in addition a considerable amount of heat from the cooling ware is recovered and usefully employed in the burning of the fuel by the preheating of the air for combustion. Exactly the same cycle of operation is employed in the compartment kiln inasmuch as the off-going products of combustion from the chamber fired directly is passing through the chambers ahead, preheating the ware, and the air for the firing of the fuel in the chamber directly fired is preheated by passing through the chambers cooling, thereby cooling the ware and at the same time obtaining the benefit from the highly heated air which shows a corresponding saving in fuel.

The tunnel kiln requires an exact setting of the ware on the trucks to obtain a uniform circulation of heat, but the compartment kiln can be set by any of the known and employed methods in the periodic kiln and still obtain the same remarkable uniformity of temperature throughout the compartment which is of the greatest importance in all cases where a variety of materials are being manufactured. Therefore, the compartment kiln has all the advantages of the tunnel kiln and still allows operation within wide limits. Furthermore, the compartment kiln permits of longer heating and cooling periods which is so essential in the firing of a great variety of ware and will allow of a compact kiln without impairing the firing capacity of the kiln. To obtain similar results with the tunnel type of kiln would require a kiln of enormous length which often does not fit in with the best factory construction. So far as I know, there has never been made any direct comparison of the fuel consumption of the tunnel type of kiln with the compartment chamber kiln. It is doubtful whether the former will show any advantage whatever over the latter in the matter of fuel consumption.

The compartment type of kiln originated in Germany and has been confined almost exclusively to the firing of brick. It has been adapted only to a very limited extent for the firing of other types of ceramic wares. At the former Royal Berlin Works, there is a small compartment kiln of 22 chambers which is used for the firing of hard porcelain. This, of course,

[1] W. R. Richardson, *Jour. Am. Ceram. Soc.*, **5**, 254 (1922).

is a very small kiln as compared with the Hoffman, and similar kilns used for firing brick.

Within the last four or five years, there has been developed in England, a compartment kiln known as the "Shaw Gas Kiln," which has been especially designed and adapted to the firing of the finer grades of ware as well as brick. This is a kiln consisting of 16, or more, chambers, fired with producer gas. At the present time there are two in operation in France and 21 in England, while a number of others are in process of being built. During the past three or four years, the General Ceramics Company has experimented with practically every type of tunnel kiln in the firing of fire clay sanitary ware. None of the trials that were made proved successful, although it can not be said definitely that they might not have been successful under different conditions. However, after investigating every type of kiln, the conclusion was reached that the Shaw kiln was better adapted to this class of ware than any other type so far developed. At the present time two of these kilns are being built in America—one for vitreous sanitary ware and the other for fire clay sanitary ware.

This kiln is now being operated in England for the firing of enameled brick, fire brick, glazed wall tile, architectural terra cotta, vitreous sanitary ware, fire clay sanitary ware, fancy art ware, high-grade pottery, electrical porcelain, general dinner ware and various kinds of bricks, including silica brick. The kiln is being used for the various articles for both the biscuit and glazed firings. In fact, it has been used for practically every type of ware except salt glazed ware.

The operation of this kiln is remarkable for its elasticity, as it may be made to fire quickly or slowly on account of the firing being under absolute control. For this reason it is possible to fire different kinds of ware at different temperatures in the different chambers. On account of the control of the firing, it is possible to regulate the atmosphere of the burning chamber to produce either oxidizing or reducing conditions, as desired. It has been found possible to fire glazed ware without the use of a muffle or sagger on account of the freedom from sulphur, smoke and ash. In firing the kinds of ware which require saggers for placing, it has been found that the life of the sagger is from three to five times as long as in the ordinary kiln.

On account of the ease of operation and the use of a gas producer, the amount of labor in connection with firing this kiln is remarkably low. It has been demonstrated that one man is quite able to handle the firing of the kiln during any shift. The labor of handling the coal and ashes is very remarkably reduced because of the great economy due to perfect fuel combustion. It has been found that the temperature of the burning gases as they pass into the stack are about 100 to 150° centigrade and that all smoke is consumed in the combustion chambers.

The fuel economy in connection with the operation of this kiln seems quite remarkable and in some cases almost beyond belief. In connection with the firing of fire clay sanitary ware, it has been found that the coal consumption amounts to about 15% of what is required for firing of periodical kilns which are believed to be operated quite efficiently. This, of course, is a very remarkable saving. One of the reasons for this is that it is possible in this kiln to fire glazed ware without the use of a muffle, resulting in a very great fuel saving aside from the more complete combustion of gases and the use of the waste heat. This same saving of fuel has been noted in connection with the firing of the various kinds of ware which are being fired in this kiln. For instance, fire brick fired to cone 10 have required a fuel consumption of 400 lbs. per thousand bricks. As the English brick are 3″ thick as against $2^1/_2$″ for the American brick, this consumption would be slightly less in America. For terra cotta ware, the consumption of coal has averaged about 17 tons per 100 tons of ware.

On account of the uniformity of the temperature in each of the chambers and the control of the gases, it is possible to obtain a higher quality of product than is usual with the ordinary kiln. The combustion air passes through six (6) chambers and the heat from the chamber being fired, also passes through six (6) chambers. In a kiln of 16 compartments, this leaves four (4) chambers free for setting and discharging. The actual fire time varies with the class of ware and ranges from 10 hours for table ware glost to 24 hours for heavy fire clay sanitary ware. The firing time governs the number of chambers that may be discharged per week, ranging from 7 to 16 chambers. On account of the preheating of the chambers, the firing and cooling curves are remarkably uniform, resulting in great economy of fuel and remarkable uniformity of quality of the ware throughout the chamber.

As soon as the kilns now being built are completed, an opportunity will be presented for acquiring data on their operation as compared with tunnel kilns and periodic kilns. There is no doubt but what the compartment type of kiln will receive more attention in the future in connection with the firing of all types of ceramic wares.

DISCUSSION ON "LAMINATIONS, DISCUSSION OF CAUSE AND CURE"[1]

By R. B. Keplinger:—Mr. Brand's nomenclature and definitions applying to the two forms of lamination seem to meet all requirements. The local terminology for these two types is "differential" and "auger" lamination, for which latter the term "interfacial" is probably more inclusive and broader in description.

It is believed, with Mr. Lovejoy, that distortion of the clay blank in the

[1] *Jour. Am. Ceram. Soc.*, **5**, 355 (1922).

mould box under pressure of the repress plunger simply serves to intensify the separation of the clay along the planes of the laminae already included in the blank—if even this is the case, which our experience has gone far to disprove. In paving brick manufacture it is mainly desired to remedy the extreme type of differential lamination, which is generally more marked at the ends of the block than on the top and bottom surfaces, as of course the ends are already the weakest portion structurally of the block unit. The familiar herring-bone evidence of interfacial lamination, when present in marked degree, is usually so far in the interior of the block that the grind of traffic or the abrasion of the rattler will not discover a structural weakness. Fairly consistent evidence can be cited that repressing actually tends to "heal" or reunite the laminated surfaces at the ends of the block and while holding no brief for the repressing process we have less difficulties securing sound ends manufacturing repressed block, than straight wire-cut or bulged end block. This of course applies only to this material, a fairly gritty shale. Furthermore, in burning, the ends of the block exposed to the impinging action of the flame, creating differential shrinkage strains, will show intensified lamination when compared with thoroughly vitrified ware from the lower middle courses. These latter are subjected to the very considerable weight of the upper courses, which tends again to heal these lamination planes when heated to incipient viscosity in the course of the burning.

I do not quite agree with all Mr. Brand says about die lamination and the action of the clay in the nozzle and die of the machine. Mr. Claude Fuller's experiments at Buffalo, Kansas, using a well known standard make of paving brick machine, first convinced me of the soundness of the "interlocking cone" theory of clay bar structure. He demonstrated this, quite ingeniously, by painting a cross section of the clay at the throat of the machine and then replacing extension and die; he ran the bar out, dried it and carefully dissected it to uncover the painted surfaces. This of course would not demonstrate the action of the auger upon the clay except subsequent to the clay passing the point of the auger. It was found necessary, at Buffalo, to reduce the taper of the nozzle and slightly extend its length, thus reducing the friction and resistance to the passage of the clay, producing a shorter "cone" length and lessening the differential flow. We have demonstrated this, at least to our partial satisfaction, after experimenting with various combinations of nozzles, extensions, dies and augers. When one considers the fact that on a great many paving brick plants the passage for the clay is reduced from a fifteen-inch auger diameter to the rear opening of the die whose finished size is approximately 4 inches by 9 inches, in a lineal measurement of but a few inches, it is almost impossible not to conceive of the tremendous differential stresses involved.

In endeavoring to remedy this differential flow the experimenter is lim-

ited by the design of the standard type of machine. To approximate a straighter nozzle one must reduce the diameter of the tapered nozzle at the larger end. This reduces the wing surface with respect to the size of the hub, so we must have smaller hubs, hence smaller shafts. If we can go this far we find we have a greatly reduced capacity. This can be remedied by speeding up the R.P.M. or by increasing the pitch of the augers and propeller whether of single or double wing type. At this point it will probably be profitable to scrap the machine and re-design one to suit the requirements.

At the present time I have before me a blue print showing the nozzle lengths, and reduction in diameter of these nozzles from rear to discharge end, of twenty-two standard brick machines with which paving brick can be made. These nozzle lengths vary from one foot to twenty-eight inches, and the reduction in diameter shown by these nozzles runs from three inches to thirteen inches. Yet all of these machines are supposed to be capable of turning out A–1 paving block from shales having similar properties and qualities.

Whether, by returning the clay to the machine often enough, differential lamination will disappear, appears rather doubtful and extremely difficult of proof. Mr. Brand's assumption that by increasing the lines of cleavage until it is impossible to further subdivide the clay layers, he will secure a clay which for all intents and purposes, will be non-laminated and with a lower plasticity, might hold if the cleavage planes and layers of clay ran in the same direction and were superimposed with each journey through the machine. Otherwise it would seem to be necessary to run it through an infinite number of times. My experience has been that when our material has been run through more than two or three times it is unfit for the manufacture of paving brick. I agree that increasing the distance between the die and the auger will help to eliminate auger or interfacial lamination in gritty clays; but have also found that it increases the differential flow. This is more clearly emphasized by the large increase of power consumption when this dimension is appreciably lengthened. It would be perfectly possible, theoretically, to arrive at a certain distance of the die from the auger, at which distance it would be impossible to apply sufficient power to the machine to operate it, without wrecking it.

Mr. Brand's theory of occluded air must certainly be received with respect. It furnishes a reasonably satisfactory answer for many obscure results, such as the "bulge" or swelling of the column at the die. As to whether the blisters that form on the surface of the column of clay are due to the expansion of occluded air or to other internal strains or stresses within the bar, causing a surface lamination which, released from confinement of the die, or due to incipient surface drying, cracks or bursts open, I can hazard no conclusion.

DISCUSSION "NOTES ON DIAGNOSING CAUSES OF CORDS IN GLASS"[1]

By F. Gelstharp:—Any devised method of diagnosing defects in glass which goes beyond the possibilities of chemical analysis is deserving of much credit even if it gives nothing more than a suggestion as to the cause. Mr. Twyman by means of optical methods enables the chemist to obtain certain properties of the particular defect known as cords, which may in some cases lead the way to their elimination.

Cords have always been considered as a glass varying more or less in composition from that of the general mass. And my experience has been that a chemical analysis of the cord and surrounding glass compared with that of the glass free from cord will show an excessive amount of alumina and silica sometimes associated with an excessive amount of lime, but in the latter case it has often been traced directly to localized impurities in the limestone, whereas, where the lime content corresponded with the alkali, the presence of cords has been due to solution of clay, no doubt originating from the furnace or tank walls, entering the glass as a drop from overhanging clay work. Often such drop formed cords are colored more or less by impurities in the clay. I have generally been able to diagnose the cause of cords by making painstaking chemical analysis, and I personally welcome the rapid optical methods described by Mr. Twyman as they provide further data which would help one to draw the right conclusions, in many cases making it unnecessary to obtain a chemical analysis. And where the cord was very slight (in which case a chemical analysis would be unsatisfactory). The optical method would at least give some clue.

DISCUSSION ON "MICROSCOPIC STUDY OF GROUND COAT AND COVER COAT ENAMEL REACTIONS"[1]

By B. T. Sweely:—Mr. Geisinger has opened a new field to investigation in the enamel industry. I think the author is to be congratulated on his very careful work and on the very able preparation and presentation of the data contained in this paper.

Unfortunately, Mr. Geisinger's results and conclusions are not applicable to the sheet steel enamel industry, directly. His work has been confined entirely to the fishscaling and shivering of finish enamels as we know them, and not to ground coats and grey ware or one coat enamels.

Light steel, such as is used for cooking ware, etc., usually will not fishscale badly, after the second coat of enamel is applied, probably because sufficient strength is secured in the two coats to resist the stress set up by

[1] F. Twyman, *Jour. Am. Ceram. Soc.*, **5**, 289 (1922).

[2] E. E. Geisinger, *Jour. Am. Ceram. Soc.*, **5**, 322 (1922).

the contracting steel. Further, most of such ware, being enameled on both sides, is further protected against failure in the characteristic fishscale form, by the fact that after the second coat of enamel is applied, there are in reality four coats of enamel to resist the stress set up by the greater contraction of steel over enamel, and consequently failure or fishscale seldom occurs on such ware in the second coat.

In enameling heavy plate, however, such as was used by Mr. Geisinger in his work, it would seem quite probable that fishscale would occur after the second coat was applied, as a very heavy steel is used and the enamel applied to one side only, the finished piece having far from sufficient enamel to counteract the stress set up by the contracting steel.

From the above, therefore, it would seem that Mr. Geisinger is dealing with and speaking of an entirely different set of conditions than those that were under investigation in the work of Danielson and Souder. The latter writers were working with thin sheet, from 22 gauge to 28 gauge steel, enameled on both sides, with but one coat of enamel, and the fishscale encountered in their work occurred in this one or first coat of enamel and not in a subsequent cover coat, and it is with this type of failure of ground coats or grey coats that the enameler usually has to contend, and not of the finish enamels. It would be interesting to know whether Mr. Geisinger has ever experienced fishscale to any great degree in his ground coats, and if so, whether the same conditions obtain in regard to the enamels resistance to fishscale as was observed in his work on cover enamels.

It has been the writer's observation, that bubble formation in ground coat enamels is very prevalent, in fact under even a low power glass, most ground coats reveal a very large number of minute bubbles, and it might well be that this bubble structure, or the lack of it, plays an important part in the fishscaling of first coat and grey ware enamels under varying conditions.

Aside from its effect on the fishscaling of finish enamels as Mr. Geisinger has so nicely shown in this paper, it has occurred to me that this bubble structure in finish enamels might play an important rôle in the resistance of kitchen ware, to thermal shock and impact. I should be very much interested in hearing from the author of this paper, whether he has ever investigated the possible relation of this structure of finish enamels to the above mentioned physical properties of enameled steel ware.

DISCUSSION ON "PAINTING IN UNDERGLAZE COLORS ON THE BISCUIT"[1]

By Paul E. Cox:—1. In Mr. Rhead's paragraphs dealing with mediums, under the heading "Painting Mediums," sub-head "Water" he

[1] F. H. Rhead, *Jour. Am. Ceram. Soc.*, **5**, 376 (1922).

notes the trouble with dusting, or rubbing of the color. It has come to my attention that one well-known studio pottery overcame this trouble very satisfactorily, in fact with entire success, by quickly dipping the painted piece into clear water just before dipping in the glaze. This set the color so that it did not wash off in the glaze, though likely enough a little was lost in the water dipping, and a trouble with "crawling" of the glaze was stopped, this "crawling" being due to the dust of the color in the thicker deposits of color. It may be noted that a little gum tragacanth had been used in the under glaze color as originally applied.

2. Under the heading "Use of Underglaze White" mention might be made of the use of a dark clay made white on the surface only by the use of a suitable engobe. Such a surface is good for underglaze painting on the unburned piece or on the biscuit, as is desired. It ought to be possible likewise to borrow from the Collected Writings of Dr. Seger, and to make use of a white ground in the form of a tin enamel, carrying the underglaze colors, the colors being covered in turn by either a clear glaze or a translucent glaze, as desired. Seger spoke of two clear glazes being so used.

3. Under the heading "Preparation of Surface for Painting" the plan followed at Newcomb Pottery for the preparation of a surface might be followed in addition to those plans enumerated. The leather hard piece is carefully sponged so that the texture lines take the direction desired by the artist, doing away with a difficulty where thin washes are used that manifests itself in streaky looking work. It is probable that experiment would reveal a number of ways of securing textures that would yield special results and secure desirable effects where light washes are used. The air brush is of course a method, where even grounds are wanted.

4. In Table I, the use of zinc oxide in both the French green and the olive green strikes one familiar with the usual effect of zinc on greens obtained from copper and chromic oxide as a thing to be studied. In ceramics no one can say a thing is impossible but this is unusual.

5. In Table III zinc oxide again appears but in relatively small amounts. The suggestion might be made that the borates offset the effects of zinc oxide in the several cases. Mr. Rhead does not indicate what the fritt proportions are in his glazes, and it will be noted that these glazes are English in origin. This is not to say that they are not good glazes on that account, but a paper of this sort appeals to the amateur as well as the professional potter, and it might be well in another paper to point out how these glazes might be made up from American materials only. It is to be supposed that the borax is in such small amounts that it functions as a soluble salt, but the ground glass is not stated as to composition. Since no bodies are named on which to make use of these glazes it might be worth while to specify all raw materials, about which there might be doubt.

6. In the use of Liquid Underglaze Colors is it possible to make use of

organic dyes as a help in application of the colors? Newcomb Pottery, acting under a suggestion from the writer, makes use of carbonate of copper as an underglaze green, and as this is a precipitated material this has proven a very satisfactory underglaze color. Doubtless other precipitated mineral salts would prove equally satisfactory.

7. For the amateur a description of the process of ground laying used in the white ware industry would be of interest, reference being made to that process where cotton pads are used for the application of dusty color to an adhesive coated surface.

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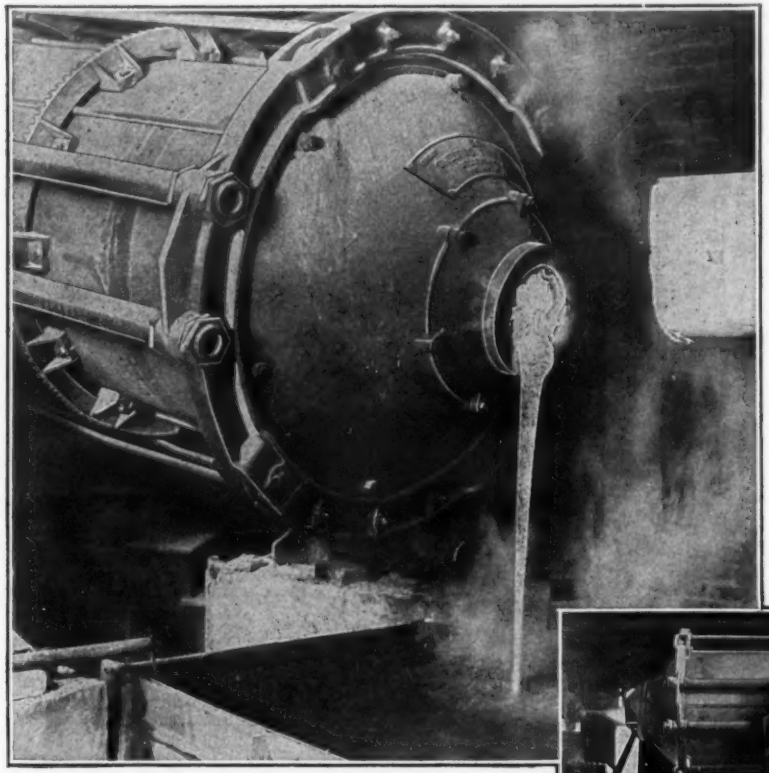

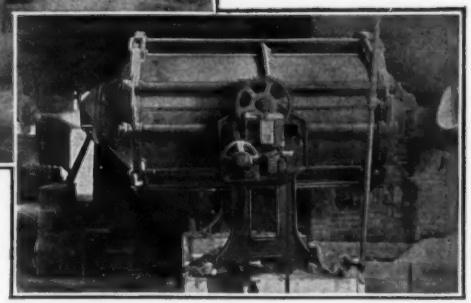

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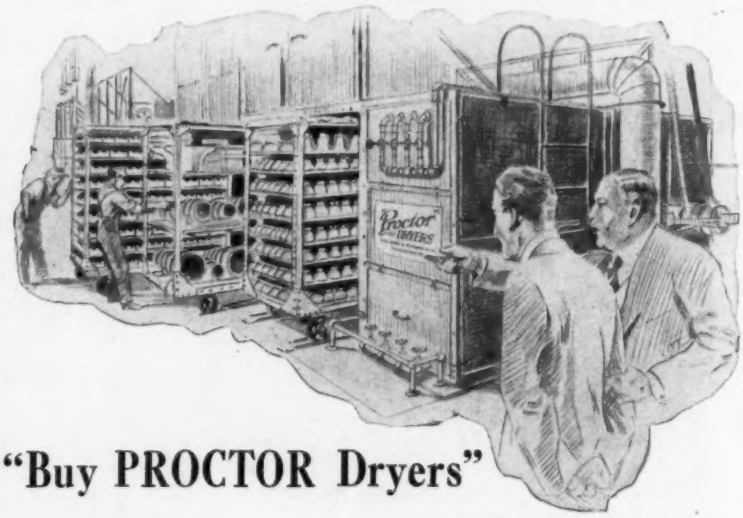

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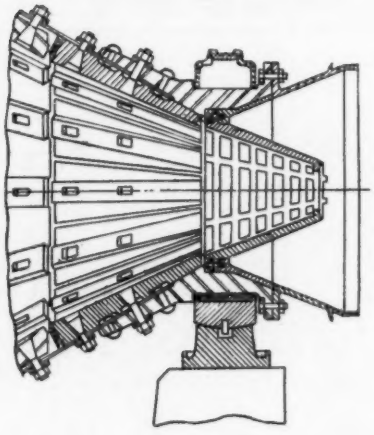

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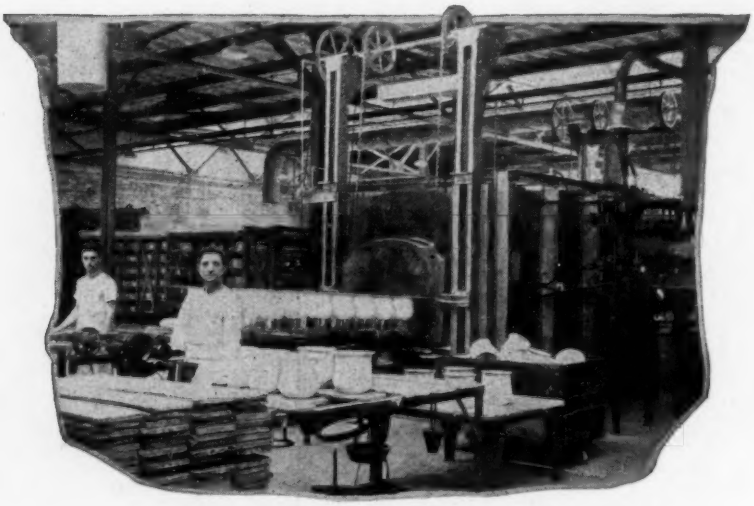

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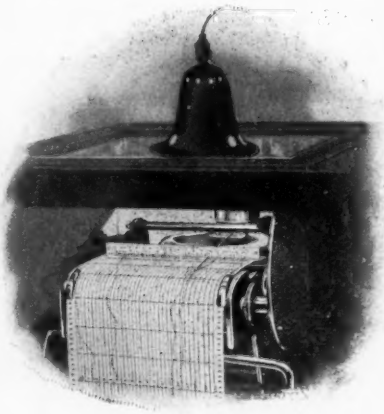

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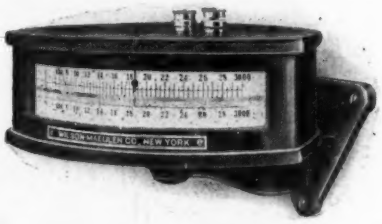

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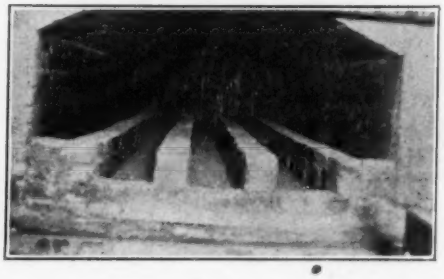

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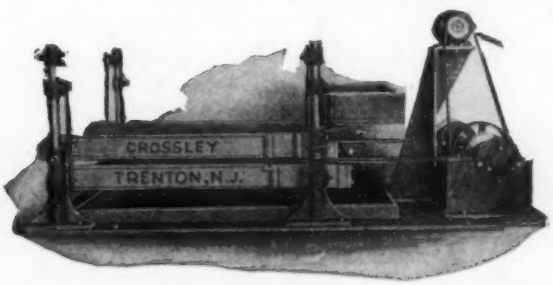

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